1. A planar light illumination module (PLIM) of compact construction for producing a planar laser illumination beam (PLIB) which emanates substantially within a single plane along the direction of beam propagation towards an object to be optically illuminated,, said PLIM comprising:
a module housing having an axial extent, first and second end portions, a central bore formed along its axial extent, and a wedge-like recess integrally formed in said second end portion;
a visible laser diode (VLD) mounted along said bore at said first end portion of said module housing, for producing a laser beam generally along said axial extent;
a focusing lens mounted along said bore between said first and second end portions, for focusing said laser beam to a predetermined focal point; and
a laser beam expansion element mounted within said wedge-like recess at said second end portion of said module housing, and expanding said laser beam along a predetermined direction and producing a substantially planar laser illumination beam from said beam expansion component.

2. The PLIM of claim 1, wherein said beam expansion component comprises a cylindrical lens element mounted within said wedge-like recess.

3. The PLIM of claim 1, wherein said focusing element is micro-oscillated so that said planar laser illumination beam is micro-oscillated laterally along its planar extent.

4. A planar laser illumination module (PLIM) for use in a PLIIM system, said PLIM comprising:
a laser diode for producing a laser beam;
a focusing lens for focusing said laser beam to its minimum beam width at a point which is the farthest distance at which said PLIIM based system is designed to capture images, and
a cylindrical lens element for expanding (i.e. spreading out) said laser beam along the direction of beam propagation so that a substantially planar laser illumination beam (PLIB) is produced, which is characterized by a plane of propagation that is coplanar with the direction of beam propagation.

5. A LED-based planar light illumination module (PLIM) of compact construction for producing a planar incoherent illumination beam (PLIB) emanated substantially within a narrow plane along the direction of beam propagation towards an object to be optically illuminated,, said PLIM comprising:
a module housing having an axial extent, first and second end portions, a central bore formed along its axial direction, and a wedge-like recess integrally formed in said second end portion;
a light emitting diode (LED) mounted along said bore at said first end portion of said module housing, for producing a diverging incoherent light beam generally along said axial direction;
a focusing lens mounted along said bore between said first and second end portions, for focusing said laser beam to a predetermined focal point; and
a light beam expansion element mounted within said wedge-like recess at said second end portion of said module housing, and expanding said incoherent light beam along a predetermined direction and producing a substantially planar light illumination beam from said beam expansion component.

6. The LED-based PLIM of claim 1, wherein said light beam expansion component comprises a cylindrical lens element mounted within said wedge-like recess.

7. The LED-based PLIM of claim 1, said module housing is realized as a compact barrel structure, containing said focusing element and said light beam expansion element.

8. An optical process carried out within an LED-based PLIM having a light emitting diode (LED) with a light emitting source, a focusing lens and a beam expanding element, said optical process comprising:
using said focusing lens to focus a reduced size image of the light emitting source of said LED towards the farthest working distance in the PLIIM-based system; and
transmitting the light rays associated with said reduced-sized image through said beam expanding element to produce a incoherent planar light illumination beam.

9. The optical process of claim 4, wherein said beam expanding element comprises a cylindrical lens element.

10. An LED-based PLIM for use in PLIIM-based systems, comprising a linear-type LED, a focusing lens, collimating lens and a cylindrical lens element, each being mounted within a compact barrel structure, for the purpose of producing a spatially-incoherent planar light illumination beam (PLIB) therefrom.

11. An optical process carried within an LED-based PLIM having a light emitting diode (LED) with a light emitting source, a focusing lens and a beam expanding element each contained within a barrel structure, said optical process comprising:
using said focusing lens to focus a reduced size image of the light emitting source of the LED towards a focal point within the barrel structure;
using said collimating lens to collimates the light rays associated with the reduced size image of the light emitting source; to produce a collimated light beam; and
Using said cylindrical lens element to expand said collimated light beam so as to produce a spatially-coherent planar light illumination beam.

12. An LED-based PLIM for use in PLIIM-based systems having relatively short working distances (e.g. less than 18 inches or so), wherein a linear-type LED, an optional focusing lens element and a cylindrical lens element are each mounted within compact barrel structure, for the purpose of producing a spatially-incoherent planar light illumination beam (PLIB) therefrom.

13. An optical process carried within an LED-based PLIM, wherein (1) the focusing lens focuses a reduced-size image of the light emitting source of the LED towards the farthest working distance in the PLIIM-based system, and (2) the light rays associated with the reduced-size of the image LED source are

transmitted through the cylindrical lens element to produce a spatially-incoherent planar light illumination beam (PLIB).

14. A LED-based PLIM for best use in PLIIM-based systems having relatively short working distances, wherein a linear-type LED, a focusing lens element, collimating lens element and a cylindrical lens element are each mounted within compact barrel structure, for the purpose of producing a spatially-incoherent planar light illumination beam (PLIB) therefrom.

15. An LED-based PLIM chip for use in PLIIM-based systems, comprising:
a semiconductor substrate supporting a linear-type light emitting diode (LED) array;
a focusing-type microlens array;
a collimating type microlens array;
an IC package with a light transmission window, for containing said semiconductor substrate, said focusing-type microlens array, and said collimating-type microlens array,
wherein each focusing lenslet focuses a reduced size image of a light emitting source of an LED towards a focal point above said focusing-type microlens array;
wherein each collimating lenslet collimates the light rays associated with the reduced size image of the light emitting source; and
wherein each cylindrical lenslet diverges the collimated light beam so as to produce a spatially-coherent planar light illumination beam (PLIB) component, which collectively produce a composite PLIB from the LED-based PLIM.

16. An LED-based PLIM chip for use in PLIIM-based systems having relatively short working distances, wherein a linear-type light emitting diode (LED) array, a focusing-type microlens array, collimating type microlens array, and a cylindrical-type microlens array are each mounted within the IC package of the PLIM chip, for the purpose of producing a spatially-incoherent planar light illumination beam (PLIB) therefrom.

17. An optical process carried within the LED-based PLIM, wherein (1) the focusing lens element focuses a reduced-size image of the light emitting source of the LED towards a focal point within the barrel structure, (2) the collimating lens element collimates the light rays associated with the reduced-size image of the light emitting source, and (3) the cylindrical lens element diverges (i.e. spreads) the collimated light beam so as to produce a spatially-incoherent planar light illumination beam (PLIB).

18. An optical process carried within the LED-based PLIM, wherein (1) each focusing lenslet focuses a reduced-size image of a light emitting source of an LED towards a focal point above the focusing-type microlens array, (2) each collimating lenslet collimates the light rays associated with the reduced-size image of the light emitting source, and (3) each cylindrical lenslet diverges the collimated light beam so

as to produce a spatially-incoherent planar light illumination beam (PLIB) component, which collectively produce a composite spatially-incoherent PLIB from the LED-based PLIM.

19. A LED-based PLIM comprises:
a light emitting diode (LED), realized on a semiconductor substrate, and having a small and narrow (as possible) light emitting surface region (i.e. light emitting source);
a focusing lens for focusing a reduced-size image of the light emitting source to its focal point, which typically will be set by the maximum working distance of the system in which the PLIM is to be used; and
a cylindrical lens element beyond the focusing lens, for diverging or spreading out the light rays of the focused light beam along a planar extent to produce a spatially-incoherent planar light illumination beam (PLIB), while the height of the PLIB is determined by the focusing operations achieved by the focusing lens; and
a compact barrel or like structure, for containing and maintaining the above described optical components in optical alignment, as an integrated optical assembly.

20. The LED-based PLIM of claim 19, wherein the focusing lens used in LED-based PLIM is characterized by a large numerical aperture (i.e. a large lens having a small F #), and the distance between the light emitting source and the focusing lens is made as large as possible to maximize the collection of the largest percentage of light rays emitted therefrom, within the spatial constraints allowed by the particular design.

21. The LED-based PLIM of claim 19, wherein the distance between said cylindrical lens and the focusing lens is selected so that beam spot at the point of entry into said cylindrical lens is sufficiently narrow in comparison to the width dimension of the cylindrical lens.

22. The LED-based PLIM of claim 19, wherein a flat-top LED is used to construct said LED-based PLIM, as the resulting optical device can produce a collimated light beam, enabling a smaller focusing lens to be used without loss of optical power.

23. The LED-based PLIM of claim 19, wherein the spectral composition of the LED can be associated with any or all of the colors in the visible spectrum, including "white" type light which is useful in producing color images in diverse applications in both the technical and fine arts.

24. The LED-based PLIM of claim 19, wherein said focusing lens focuses a reduced size image of the light emitting source of the LED towards the farthest working distance in the PLIIM-based system.

25. The LED-based PLIM of claim 19, wherein the light rays associated with the reduced-sized image are transmitted through said cylindrical lens element to produce the spatially-incoherent planar light illumination beam (PLIB).

26. A PLIM comprising:
a light emitting diode (LED) having a small and narrow (as possible) light emitting surface region (i.e. light emitting source) realized on a semiconductor substrate;
a focusing lens (having a relatively short focal distance) for focusing a reduced size image of the light emitting source to its focal point;
a collimating lens located at about the focal point of the focusing lens, for collimating the light rays associated with the reduced size image of the light emitting source; and
a cylindrical lens element located closely beyond the collimating lens, for diverging the collimated light beam substantially within a planar extent to produce a spatially-incoherent planar light illumination beam (PLIB); and
a compact barrel or like structure, for containing and maintaining the above described optical components in optical alignment, as an integrated optical assembly.

27. The PLIM of claim 26, wherein said focusing lens is characterized by a large numerical aperture (i.e. a large lens having a small F #), and the distance between said light emitting source and the focusing lens be as large as possible to maximize the collection of the largest percentage of light rays emitted therefrom, within the spatial constraints allowed by the particular design.

28. The PLIM of claim 26, wherein a flat-top LED is used to construct the PLIM as the resulting optical device will produce a collimated light beam, enabling a smaller focusing lens to be used without loss of optical power.

29. The PLIM of claim 26, wherein the spectral composition of the LED can be associated with any or all of the colors in the visible spectrum, including "white" type light which is useful in producing color images in diverse applications.

30. The PLIM of claim 26, wherein the focusing lens focuses a reduced size image of the light emitting source of the LED towards a focal point at about which the collimating lens is located.

31. The PLIM of claim 26, wherein the light rays associated with the reduced-sized image are collimated by the collimating lens and then transmitted through the cylindrical lens element to produce said spatially-incoherent planar light illumination beam (PLIB).

32. A LED-based PLIM is realized as an array of components, contained within a miniature IC package, namely:

a linear-type light emitting diode (LED) array, on a semiconductor substrate, providing a linear array of light emitting sources (having the narrowest size and dimension possible);

a focusing-type microlens array, mounted above and in spatial registration with the LED array, providing a focusing-type lenslet above and in registration with each light emitting source, and projecting a reduced image of the light emitting source at its focal point above the LED array;

a collimating-type microlens array, mounted above and in spatial registration with the focusing-type microlens array, providing each focusing lenslet with a collimating-type lenslet for collimating the light rays associated with the reduced image of each light emitting device;

a cylindrical-type microlens array, mounted above and in spatial registration with the collimating-type micro-lens array, providing each collimating lenslet with a linear-diverging type lenslet for producing a spatially-incoherent planar light illumination beam (PLIB) component from each light emitting source; and

an IC package containing the above-described components in the stacked order described above, and having a light transmission window through which the spatially-incoherent PLIB is transmitted towards the target object being illuminated.

33. A LED-based PLIM realized within an IC package design comprising:

a light emitting diode (LED) providing a light emitting source (having the narrowest size and dimension possible) on a semiconductor substrate;

focusing lenslet, mounted above and in spatial registration with the light emitting source, for projecting a reduced image of the light emitting source at its focal point, which is preferably set by the further working distance required by the application at hand;

a cylindrical-type microlens, mounted above and in spatial registration with the collimating-type microlens, for producing a spatially-incoherent planar light illumination beam (PLIB) from the light emitting source; and

an IC package containing the above-described components in the stacked order described above, and having a light transmission window through which the composite spatially-incoherent PLIB is transmitted towards the target object being illuminated.

34. A miniature planar laser illumination module (PLIM) on a semiconductor chip that can be fabricated by aligning and mounting a micro-sized cylindrical lens array upon a linear array of surface emit lasers (SELs) formed on a semiconductor substrate, encapsulated (i.e. encased) in a semiconductor package provided with electrical pins and a light transmission window, and emitting laser emission in the direction normal to the semiconductor substrate.

35. A miniature planar laser illumination module (PLIM) on a semiconductor, wherein the laser output therefrom is a planar laser illumination beam (PLIB) composed of numerous (e.g. 100-400 or more) spatially incoherent laser beams emitted from the linear array of SELs.

36. A miniature planar laser illumination module (PLIM) on a semiconductor, wherein each SEL in the laser diode array can be designed to emit coherent radiation at a different characteristic wavelengths to produce an array of laser beams which are substantially temporally and spatially incoherent with respect to each other.

37. A PLIM-based semiconductor chip, which produces a temporally and spatially coherent-reduced planar laser illumination beam (PLIB) capable of illuminating objects and producing digital images having substantially reduced speckle-noise patterns observable at the image detector of the PLIIM-based system in which the PLIM is employed.

38. A PLIM-based semiconductor which can be made to illuminate objects outside of the visible portion of the electromagnetic spectrum (e.g. over the UV and/or IR portion of the spectrum).

39. A PLIM-based semiconductor chip which embodies laser mode-locking principles so that the PLIB transmitted from the chip is temporal intensity-modulated at a sufficient high rate so as to produce ultra-short planes light ensuring substantial levels of speckle-noise pattern reduction during object illumination and imaging applications.

40. A PLIM-based semiconductor chip which contains a large number of VCSELs (i.e. real laser sources) fabricated on semiconductor chip so that speckle-noise pattern levels can be substantially reduced by an amount proportional to the square root of the number of independent laser sources (real or virtual) employed therein.

41. A miniature planar laser illumination module (PLIM) on a semiconductor chip which does not require any mechanical parts or components to produce a spatially and/or temporally coherence reduced PLIB during system operation.

42. A planar laser illumination module (PLIM) realized on a semiconductor chip, wherein a micro-sized (diffractive or refractive) cylindrical lens array is mounted upon a linear array of surface emitting lasers (SELs) fabricated on a semiconductor substrate, and encased within an integrated circuit (IC) package, so as to produce a planar laser illumination beam (PLIB) composed of numerous (e.g. 100-400) spatially incoherent laser beam components emitted from said linear array of SELs.

43. The PLIM semiconductor chip of claim 42, wherein its semiconductor package is provided with electrical connector pins and an elongated light transmission window, through which a planar laser illumination beam is generated and transmitted.

44. The PLIM-based semiconductor chip of claim 42, wherein said SELs are constructed from “45 degree mirror” surface emitting lasers (SELs);

45. The PLIM-based semiconductor chip of claim 42, wherein said SELs are constructed from "grating-coupled" SELs.

46. The PLIM-based semiconductor chip of claim 42, wherein said SELs are constructed from "vertical cavity" SELs, or VCSELs.

47. A system for illuminating an object and forming an image thereof, comprising:
an image formation and detection module having a field of view (FOV) focused at an image detecting array; and
a planar laser illumination array (PLIA) for producing a planar laser illumination beam (PLIB) having substantially-planar spatial distribution characteristics that extend through the field of view (FOV) of said image formation and detection module, so that laser light reflected off an object illuminated by said planar laser illumination beam is focused along said field of view and onto said image detecting array to form an image of said illuminated object.

48. The system of claim 47, wherein said planar laser illumination beam array comprises a plurality of planar laser illumination modules, wherein each said planar laser illumination module comprises a visible laser diode (VLD), a focusing lens, and a cylindrical optical element arranged therewith to produce a planar laser illumination beam component.

49. The system of claim 47, wherein the individual planar laser illumination beam components produced from said plurality of planar laser illumination modules are optically combined to produce a composite substantially planar laser illumination beam having substantially uniform power density characteristics over the entire spatial extent thereof and thus the working range of the system.

50. The system of claim 49, wherein each said planar laser illumination beam component is focused so that the minimum beam width thereof occurs at a point or plane which is the farthest or maximum object distance at which the system is designed to acquire images, thereby compensating for decreases in the power density of the incident planar laser illumination beam due to the fact that the width of the planar laser illumination beam increases in length for increasing object distances away from the imaging optics.

51. The system of claim 47, wherein said planar light illumination beam (PLIB) and the magnified field of view (FOV) are projected onto an object during conveyor-type illumination and imaging applications, wherein the height dimension of the PLIB is substantially greater than the height dimension of the magnified field of view of each image detection element in the linear CCD image detection array so as to decrease the range of tolerance that must be maintained between the PLIB and the FOV.

52. A method of illuminating an object and forming an image thereof, comprising the steps of:

providing a field of view (FOV) focused at an image detecting array; and
producing a planar laser illumination beam having substantially-planar spatial distribution characteristics that extend through said field of view (FOV) so that laser light reflected off an object illuminated by said planar laser illumination beam is focused along said field of view and onto said image detecting array to form an image of said illuminated object.

53. The method of claim 52, wherein said step (b) comprises:
producing a plurality of laser beams from a plurality of visible laser diodes (VLDs);
focusing each said laser beam through a focusing lens; and
expanding the focused laser beam through a cylindrical optical element so as to produce a substantially planar laser illumination beam component; and
optically combining the plurality of planar laser illumination beam components produce a composite substantially planar laser illumination beam having substantially uniform power density characteristics over the entire spatial extend thereof and thus the working range of the system.

54. The method of claim 53, wherein each planar laser illumination beam component is focused so that the minimum beam width thereof occurs at a point or plane which is the farthest or maximum object distance at which the system is designed to acquire images, thereby compensating for decreases in the power density of the incident planar laser illumination beam due to the fact that the width of the planar laser illumination beam increases in length for increasing object distances away from the imaging optics.

55. A system for illuminating the surface of objects using a linear array of laser light emitting devices configured together to produce a substantially planar beam of laser illumination which extends in substantially the same plane as the field of view of the linear array of electronic image detection cells of the system, along at least a portion of its optical path within its working distance,

56. The system of claim 55, wherein the linear array of electronic image detection cells are realized using charge-coupled device (CCD) technology.

57. A system for producing digital images of objects using a visible laser diode array for producing a planar laser illumination beam for illuminating the surfaces of such objects, and also an electronic image detection array for detecting laser light reflected off the illuminated objects during illumination and imaging operations.

58. A system for illuminating the surfaces of object to be imaged, using an array of planar laser illumination arrays which employ VLDs that are smaller, and cheaper, run cooler, draw less power, have longer lifetimes, and require simpler optics (because their frequency bandwidths are very small compared to the entire spectrum of visible light).

59. A system for illuminating the surfaces of objects to be imaged, wherein the VLD concentrates all of its output power into a thin laser beam illumination plane which spatially coincides exactly with the field of view of the imaging optics of the system, so very little light energy is wasted during object imaging operations.

60. A planar laser illumination and imaging system, wherein the working distance of the system can be easily extended by simply changing the beam focusing and imaging optics, and without increasing the output power of the visible laser diode (VLD) sources employed therein.

61. A planar laser illumination and imaging system, wherein each planar laser illumination beam is focused so that the minimum width thereof (e.g. along its non-spreading direction) occurs at a point or plane which is the farthest object distance at which the system is designed to capture images.

62. A planar laser illumination and imaging system, wherein a fixed focal length imaging subsystem is employed, and a laser beam focusing technique is employed to compensate for decreases in the power density of the incident planar illumination beam due to the fact that the width of the planar laser illumination beam for increases increasing distances away from the imaging subsystem.

63. A planar laser illumination and imaging system, wherein a variable focal length (i.e. zoom) imaging subsystem is employed, and a laser beam focusing technique is used to help compensate for (i) decreases in the power density of the incident illumination beam due to the fact that the width of the planar laser illumination beam (i.e. beamwidth) along the direction of the beam's planar extent increases for increasing distances away from the imaging subsystem, and (ii) any $1/r^2$ type losses that would typically occur when using the planar laser illumination beam.

64. A planar laser illumination and imaging system, wherein scanned objects need only be illuminated along a single plane which is coplanar with a planar section of the field of view of the image formation and detection module being used in the system.

65. A planar laser illumination and imaging system, wherein low-power, light-weight, high-response, ultra-compact, high-efficiency solid-state illumination producing devices, such as visible laser diodes (VLDs), are used to selectively illuminate ultra-narrow sections of a target object during image formation and detection operations, in contrast with high-power, low-response, heavy-weight, bulky, low-efficiency lighting equipment (e.g. sodium vapor lights) required by prior art illumination and image detection systems.

66. A planar laser illumination and imaging system, wherein a planar laser illumination technique enables high-speed modulation of the planar laser illumination beam, and use of simple (i.e. substantially

monochromatic) lens designs for substantially monochromatic optical illumination and image formation and detection operations.

67. A planar laser illumination and imaging system, wherein special measures are undertaken to ensure that (i) a minimum safe distance is maintained between the VLDs in each PLIM and the user's eyes using a light shield, and (ii) the planar laser illumination beam is prevented from directly scattering into the FOV of the image formation and detection module, from within the system housing.

68. A planar laser illumination and imaging system, wherein a planar laser illumination beam and the field of view of the image formation and detection module do not overlap on any optical surface within the PLIIM system.

69. A planar laser illumination and imaging system, wherein planar laser illumination beams are permitted to spatially overlap with the FOV of the imaging lens of the system only outside of the system housing, measured at a particular point beyond the light transmission window, through which the FOV is projected.

70. A planar laser illumination and imaging system, wherein planar laser illumination arrays (PLIAs) and the image formation and detection (IFD) module are mounted in strict optical alignment on an optical bench such that there is no relative motion, caused by vibration or temperature changes, is permitted between the imaging lens within the IFD module and the VLD/cylindrical lens assemblies within the PLIAs.

71. A planar laser illumination and imaging system, wherein the imaging module is realized as a photographic image recording module.

72. A planar laser illumination and imaging system, wherein the imaging module is realized as an array of electronic image detection cells having short integration time settings for high-speed image capture operations.

73. A planar laser illumination and imaging system, wherein a pair of planar laser illumination arrays are mounted about an image formation and detection module having a field of view, so as to produce a substantially planar laser illumination beam which is coplanar with the field of view during object illumination and imaging operations.

74. A planar laser illumination and imaging system, wherein an image formation and detection module projects a field of view through a first light transmission aperture formed in the system housing, and a pair of planar laser illumination arrays project a pair of planar laser illumination beams through second

set of light transmission apertures which are optically isolated from the first light transmission aperture to prevent laser beam scattering within the housing of the system.

75. A planar laser illumination and imaging system, the principle of Gaussian summation of light intensity distributions is employed to produce a planar laser illumination beam having a power density across the width the beam which is substantially the same for both far and near fields of the system.

76. A system for producing images of objects by focusing a planar laser illumination beam within the field of view of an imaging lens so that the minimum width thereof along its non-spreading direction occurs at the farthest object distance of the imaging lens.

77. A PLIIM-based system with automatic laser beam power density compensation, said PLIIM-based system comprising:
an image formation and detection module having a field of view (FOV) focused at an image detecting array; and
a planar laser illumination array (PLIA) for producing a planar laser illumination beam having substantially-planar spatial distribution characteristics that extend through the field of view (FOV) of said image formation and detection module, so that laser light reflected off an object illuminated by said planar laser illumination beam is focused along said field of view and onto said image detecting array to form an image of said illuminated object;
wherein said planar laser illumination beam having a beam width which increases as a function of increasing object distance in said PLIIM-based system; and
wherein the height of said planar laser illumination beam decreased as the object distance increases, compensating for the increase in beam width in said planar laser illumination beam which occurs for an increase in object distance,
thereby yielding a laser beam power density on the target object which increases as a function of increasing object distance over a substantial portion of the object distance range of said PLIIM-based system.

78. The PLIIM-based system of claim 77, wherein the beam height of said PLIB is substantially constant (e.g. 1 mm) over the entire portion of the object distance range of said PLIIM-based system.

79. A PLIIM-based system having near and far field regions, comprising:
a planar laser illumination array (PLIA) having a plurality of visible laser diodes (VLDs),
wherein the power density contributions of the individual visible laser diodes in the planar laser illumination array are additively combined to produce a planar laser illumination beam (PLIB) having substantially uniform power density characteristics in the near and far field regions of the system.

80. A PLIIM system comprising:

a linear image formation and detection module; and
a pair of planar laser illumination arrays arranged in relation to the image formation and detection module such that the field of view thereof is oriented in a direction that is coplanar with the plane of the stationary planar laser illumination beams produced by the planar laser illumination arrays, without using any laser beam or field of view folding mirrors.

81. A PLIIM-based system comprising:
a linear image formation and detection module;
a pair of planar laser illumination arrays;
an image frame grabber,
an image data buffer;
an image processing computer; and
a camera control computer.

82. A PLIIM-based system comprising:
a linear image formation and detection module having a field of view;
a pair of planar laser illumination arrays for producing first and second stationary planar laser illumination beams; and
a pair of stationary planar laser beam folding mirrors arranged so as to fold the optical paths of the first and second planar laser illumination beams such that the planes of the first and second stationary planar laser illumination beams are in a direction that is coplanar with the field of view of the image formation and detection module.

83. A PLIIM-based system comprising:
a linear image formation and detection module;
a stationary field of view folding mirror;
a pair of planar illumination arrays;
a pair of stationary planar laser illumination beam folding mirrors;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

84. A PLIIM-based system comprising:
a linear image formation and detection module having a field of view (FOV);
a stationary field of view (FOV) folding mirror for folding the field of view of the image formation and detection module;
a pair of planar laser illumination arrays for producing first and second stationary planar laser illumination beams; and

a pair of stationary planar laser illumination beam folding mirrors for folding the optical paths of the first and second stationary planar laser illumination beams so that planes of first and second stationary planar laser illumination beams are in a direction that is coplanar with the field of view of the image formation and detection module.

85. A PLIIM-based system comprising:
a linear-type image formation and detection module;
a stationary field of view folding mirror;
a pair of planar laser illumination arrays;
a pair of stationary planar laser beam folding mirrors;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

86. An under the-conveyor belt package identification system embodying the PLIIM-based system of claim 84.

87. A hand-supportable bar code symbol reading system embodying the PLIIM-based system of claim 84.

88. A PLIIM-based system, wherein a pair of planar laser illumination arrays (PLIAs) are mounted on opposite sides of a linear type image formation and detection (IDF) module having a field of view, such that the planar laser illumination arrays produce a plane of laser beam illumination (i.e. light) which is disposed substantially coplanar with the field of view of the image formation and detection module, and that the planar laser illumination beam and the field of view of the image formation and detection module move synchronously together while maintaining their coplanar relationship with each other as the planar laser illumination beam and FOV are automatically scanned over a 3-D region of space during object illumination and image detection operations.

89. A PLIIM-based system comprising:
an image formation and detection module having a field of view (FOV);
a field of view (FOV) folding/sweeping mirror for folding the field of view of the image formation and detection module;
a pair of planar laser illumination arrays for producing first and second planar laser illumination beams; and
a pair of planar laser beam folding/sweeping mirrors, jointly or synchronously movable with the FOV folding/sweeping mirror, and arranged so as to fold and sweep the optical paths of the first and second planar laser illumination beams so that the folded field of view of the image formation and detection module is synchronously moved with the planar laser illumination beams in a direction that is coplanar

therewith as the planar laser illumination beams are scanned over a 3-D region of space under the control of the camera control computer.

90. A PLIIM-based system comprising:
a pair of planar illumination arrays;
a pair of planar laser beam folding/sweeping mirrors;
a linear-type image formation and detection module;
a field of view folding/sweeping mirror;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

91. An over-the-conveyor belt package identification system embodying the PLIIM-based system of claim 89.

92. A presentation-type bar code symbol reading system embodying the PLIIM-based subsystem of claim 89.

93. A PLIIM-based system, wherein a pair of planar laser illumination arrays (PLIAs) are mounted on opposite sides of a linear (i.e. 1-dimensional) type image formation and detection (IFD) module having a fixed focal length imaging lens, a variable focal distance and a fixed field of view (FOV) so that the planar laser illumination arrays produce a plane of laser beam illumination which is disposed substantially coplanar with the field view of the image formation and detection module during object illumination and image detection operations carried out on bar code symbol structures and other graphical indicia which may embody information within its structure.

94. A PLIIM-based system comprising:
an image formation and detection module having a field of view (FOV); and
a pair of planar laser illumination arrays for producing first and second stationary planar laser illumination beams in an imaging direction that is coplanar with the field of view of the image formation and detection module.

95. A PLIIM-based system, wherein the linear image formation and detection module is shown comprising a linear array of photo-electronic detectors realized using CCD technology, and each planar laser illumination array is shown comprising an array of planar laser illumination modules.

96. A PLIIM-based system comprising:
a pair of planar illumination arrays;

a linear-type image formation and detection module;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

97. The PLIIM-based system of claim 96, wherein said linear type image formation and detection (IFD) module further comprises an imaging subsystem having a fixed focal length imaging lens, a variable focal distance and a fixed field of view is arranged on an optical bench, mounted within a compact module housing, and responsive to focus control signals generated by the camera control computer of the PLIIM system.

98. A PLIIM system comprising:
a linear image formation and detection (IFD) module;
a stationary field of view (FOV) folding mirror for folding the field of view of the image formation and detection module; and
a pair of planar laser illumination arrays arranged in relation to the image formation and detection module such that the folded field of view is oriented in an imaging direction that is coplanar with the stationary planes of laser illumination produced by the planar laser illumination arrays.

99. A PLIIM system comprising:
a pair of planar laser illumination arrays (PLIAs);
a linear-type image formation and detection module;
a stationary field of view of folding mirror;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

100. The PLIIM-based system of claim 100, wherein said linear type image formation and detection (IFD) module further comprises an imaging subsystem having a fixed focal length imaging lens, a variable focal distance and a fixed field of view is arranged on an optical bench, mounted within a compact module housing, and responsive to focus control signals generated by the camera control computer of the PLIIM-based system.

101. A PLIIM-based system comprising:
an image formation and detection (IFD) module having a field of view (FOV);
a pair of planar laser illumination arrays for producing first and second stationary planar laser illumination beams (PLIBs); and

a pair of stationary planar laser beam folding mirrors for folding the stationary (i.e. non-swept) planes of the planar laser illumination beams produced by the pair of planar laser illumination arrays, in an imaging direction that is coplanar with the stationary plane of the field of view of the image formation and detection module during system operation.

102. The PLIIM-based system comprising:
a pair of planar laser illumination arrays;
a linear image formation and detection module;
a pair of stationary planar laser illumination beam folding mirrors;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

103. The PLIIM-based system of claim 101, wherein said linear image formation and detection (IFD) module further comprises an imaging subsystem having fixed focal length imaging lens, a variable focal distance and a fixed field of view is arranged on an optical bench, mounted within a compact module housing, and responsive to focus control signals generated by the camera control computer of the PLIIM-based system.

104. A PLIIM-based system comprising:
a linear image formation and detection module having a field of view (FOV);
a stationary field of view (FOV) folding mirror;
a pair of planar laser illumination arrays for producing first and second stationary planar laser illumination beams; and
a pair of stationary planar laser beam folding mirrors arranged so as to fold the optical paths of the first and second stationary planar laser illumination beams so that these planar laser illumination beams are oriented in an imaging direction that is coplanar with the folded field of view of the linear image formation and detection module.

105. A PLIIM-based system comprising:
a pair of planar illumination arrays;
a linear image formation and detection module;
a stationary field of view (FOV) folding mirror;
a pair of stationary planar laser illumination beam folding mirrors;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

106. The PLIIM-based system of claim 104, wherein said linear-type image formation and detection (IFD) module further comprises an imaging subsystem having a fixed focal length imaging lens, a variable focal distance and a fixed field of view is arranged on an optical bench, mounted within a compact module housing, and responsive to focus control signals generated by the camera control computer of the PLIIM-based system.

107. An over-the-conveyor belt package identification system embodying the PLIIM-based system of claim 104.

108. A hand-supportable bar code symbol reading system embodying the PLIIM-based system of claim 104.

109. A PLIIM-based system, wherein a pair of planar laser illumination arrays (PLIAs) are mounted on opposite sides of a linear image formation and detection (IFD) module having a fixed focal length imaging lens, a variable focal distance and fixed field of view (FOV), so that the planar illumination arrays produces a plane of laser beam illumination which is disposed substantially coplanar with the field view of the image formation and detection module and synchronously moved therewith while the planar laser illumination beams are automatically scanned over a 3-D region of space during object illumination and imaging operations.

110. A PLIIM-based system comprising:
an image formation and detection (i.e. camera) module having a field of view (FOV);
a field of view (FOV) folding/sweeping mirror;
a pair of planar laser illumination arrays for producing first and second planar laser illumination beams; and
a pair of planar laser beam folding/sweeping mirrors, jointly movable with the FOV folding/sweeping mirror, and arranged so that the field of view of the image formation and detection module is coplanar with the folded planes of first and second planar laser illumination beams, and the coplanar FOV and planar laser illumination beams are synchronously moved together while the planar laser illumination beams and FOV are scanned over a 3-D region of space containing a stationary or moving bar code symbol or other graphical structure (e.g. text) embodying information.

111. A PLIIM-based system comprising:
a pair of planar illumination arrays;
a linear image formation and detection module;
a field of view (FOV) folding/sweeping mirror;
a pair of planar laser illumination beam folding/sweeping mirrors jointly movable therewith;
an image frame grabber;

an image data buffer;
an image processing computer; and
a camera control computer.

112. The PLIIM-based system of claim 110, wherein said linear type image formation and detection (IFD) module further comprises an imaging subsystem having a fixed focal length imaging lens, a variable focal distance and a fixed field of view is arranged on an optical bench, mounted within a compact module housing, and responsive to focus control signals generated by the camera control computer of the PLIIM-based system.

113. A hand-supportable bar code symbol reader embodying the PLIIM-based system of claim 110.

114. A presentation-type bar code symbol reader embodying the PLIIM-based system of claim 110.

115. A PLIIM-based system, wherein a pair of planar laser illumination arrays (PLIAs) are mounted on opposite sides of a linear image formation and detection (IFD) module having a variable focal length imaging lens, a variable focal distance and a variable field of view, so that the planar laser illumination arrays produce a stationary plane of laser beam illumination (i.e. light) which is disposed substantially coplanar with the field view of the image formation and detection module during object illumination and image detection operations carried out on bar code symbols and other graphical indicia by the PLIIM-based system of the present invention.

116. A PLIIM-based system comprising:
an image formation and detection module; and
a pair of planar laser illumination arrays arranged in relation to the image formation and detection module such that the stationary field of view thereof is oriented in an imaging direction that is coplanar with the stationary plane of laser illumination produced by the planar laser illumination arrays, without using any laser beam or field of view folding mirrors.

117. The PLIIM-based system of claim 116, wherein said linear image formation and detection module comprises a linear array of photo-electronic detectors realized using CCD technology, and each planar laser illumination array is shown comprising an array of planar laser illumination modules.

118. A PLIIM-based comprising:
a pair of planar laser illumination arrays;
a linear image formation and detection module;
an image frame grabber;
an image data buffer;

an image processing computer; and
a camera control computer.

119. The PLIIM-based system of claim 116, wherein said linear type image formation and detection (IFD) module further comprises an imaging subsystem having a variable focal length imaging lens, a variable focal distance and a variable field of view is arranged on an optical bench, mounted within a compact module housing, and responsive to zoom and focus control signals generated by the camera control computer of the PLIIM-based system.

120. The PLIIM-based system of claim 116, wherein said IPD camera subsystem contained in the image formation and detection (IFD) module comprises a stationary lens system mounted before a stationary linear image detection array, a first movable lens system for large stepped movement relative to the stationary lens system during image zooming operations, and a second movable lens system for small stepped movements relative to the first movable lens system and the stationary lens system during image focusing operations.

121. The PLIIM-based system of claim 120, wherein said the first movable lens system comprises an electrical rotary motor mounted to a camera body, an arm structure mounted to the shaft of the motor, a slidable lens mount (supporting a first lens group) slidably mounted to a rail structure, and a linkage member pivotally connected to the slidable lens mount and the free end of the arm structure so that, as the motor shaft rotates, the slidable lens mount moves along the optical axis of the imaging optics supported within the camera body.

122. The PLIIM-based system comprising:
a linear image formation and detection module;
a pair of planar laser illumination arrays; and
a stationary field of view (FOV) folding mirror arranged in relation to the image formation and detection module such that the stationary field of view thereof is oriented in an imaging direction that is coplanar with the stationary plane of laser illumination produced by the planar laser illumination arrays, without using any planar laser illumination beam folding mirrors.

123. A PLIIM-based system comprising:
a pair of planar illumination arrays;
a linear image formation and detection module;
a stationary field of view (FOV) folding mirror;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

124. The PLIIM-based system of claim 122, wherein said linear type image formation and detection module (IFDM) further comprises an imaging subsystem having a variable focal length imaging lens, a variable focal distance and a variable field of view is arranged on an optical bench, mounted within a compact module housing, and responsive to zoom and focus control signals generated by the camera control computer of the PLIIM-based system.

125. A PLIIM-based system comprising:
a compact housing;
a linear-type image formation and detection (i.e. camera) module;
a pair of planar laser illumination arrays; and
a field of view (FOV) folding mirror for folding the field of view of the image formation and detection module in a direction that is coplanar with the plane of composite laser illumination beam produced by the planar laser illumination arrays.

126. The PLIIM-based system of claim 125, wherein the field of view of said linear image formation and detection module is folded in the downwardly imaging direction by the field of view folding mirror, and the planar laser illumination beam produced by each planar laser illumination module being directed in the imaging direction such that both the folded field of view and planar laser illumination beams are arranged in a substantially coplanar relationship during object illumination and imaging operations.

127. The PLIIM-based system of claim 125, wherein the field of view of the linear image formation and detection module is folded in the downwardly imaging direction by the field of view folding mirror, and the planar laser illumination beam produced by each planar laser illumination module being directed along the imaging direction such that both the folded field of view and stationary planar laser illumination beams are arranged in a substantially coplanar relationship during object illumination and image detection operations.

128. A PLIIM-based system comprising:
a linear image formation and detection module having a field of view (FOV);
a pair of planar laser illumination arrays for producing first and second stationary planar laser illumination beams; and
a pair of stationary planar laser illumination beam folding mirrors arranged relative to the planar laser illumination arrays so as to fold the stationary planar laser illumination beams produced by the pair of planar illumination arrays in an imaging direction that is coplanar with stationary field of view of the image formation and detection module during illumination and imaging operations.

129. A PLIIM-based system comprising:
a pair of planar illumination arrays; a linear image formation and detection module;

a pair of stationary planar laser illumination beam folding mirrors;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

130. The PLIIM-based system of claim 128, wherein said linear type image formation and detection module (IFDM) further comprises an imaging subsystem having a variable focal length imaging lens, a variable focal distance and a variable field of view is arranged on an optical bench, mounted within a compact module housing, and is responsive to zoom and focus control signals generated by the camera control computer of the PLIIM-based system during illumination and imaging operations.

131. A PLIIM-based system comprising:
a linear image formation and detection (i.e. camera) module having a field of view (FOV);
a pair of planar laser illumination arrays for producing first and second stationary planar laser illumination beams;
a stationary field of view (FOV) folding mirror for folding the field of view of the image formation and detection module; and
a pair of stationary planar laser beam folding mirrors arranged so as to fold the optical paths of the first and second planar laser illumination beams such that stationary planes of first and second planar laser illumination beams are in an imaging direction which is coplanar with the field of view of the image formation and detection module during illumination and imaging operations.

132. A PLIIM system comprising:
a pair of planar illumination arrays;
a linear image formation and detection module;
a stationary field of view (FOV) folding mirror;
a pair of stationary planar laser illumination beam folding mirrors;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

133. The PLIIM-based system of claim 131, wherein the linear type image formation and detection module (IFDM) which further comprises an imaging subsystem having a variable focal length imaging lens, a variable focal distance and a variable field of view is arranged on an optical bench, mounted within a compact module housing, and responsive to zoom and focus control signals generated by the camera control computer of the PLIIM system during illumination and imaging operations.

134. An over-the-conveyor and side-of conveyor belt package identification systems embodying the PLIIM-based system of claim 131.

135. A hand-supportable bar code symbol reading device embodying the PLIIM-based system of claim 131.

136. A PLIIM-based system, wherein a pair of planar laser illumination arrays (PLIAs) are mounted on opposite sides of a linear image formation and detection (IFD) module having a variable focal length imaging lens, a variable focal distance and a variable field of view, so that the planar illumination arrays produce a plane of laser beam illumination which is disposed substantially coplanar with the field view of the image formation and detection module and synchronously moved therewith as the planar laser illumination beams are scanned across a 3-D region of space during object illumination and image detection operations.

137. A PLIIM-based system comprising:
an image formation and detection module having a field of view (FOV);
a pair of planar laser illumination arrays for producing first and second planar laser illumination beams;
a field of view folding/sweeping mirror for folding and sweeping the field of view of the image formation and detection module; and
a pair of planar laser beam folding/sweeping mirrors jointly movable with the FOV folding/sweeping mirror and arranged so as to fold the optical paths of the first and second planar laser illumination beams so that the field of view of the image formation and detection module is in an imaging direction that is coplanar with the planes of first and second planar laser illumination beams during illumination and imaging operations.

138. A PLIIM-based system comprising:
a pair of planar illumination arrays;
a linear image formation and detection module;
a field of view folding/sweeping mirror;
a pair of planar laser illumination beam folding/sweeping mirrors;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

139. The PLIIM-based system of claim 137, wherein said linear type image formation and detection (IFD) module further comprises an imaging subsystem having a variable focal length imaging lens, a variable focal distance and a variable field of view is arranged on an optical bench, mounted within a

compact module housing, and responsive to zoom and focus control signals generated by the camera control computer of the PLIIM system during illumination and imaging operations.

140. A hand-held bar code symbol reading system embodying the PLIIM-based subsystem of claim 137.

141. A presentation-type hold-under bar code symbol reading system embodying the PLIIM subsystem of claim 137.

142. A PLIIM-based system, wherein a pair of planar laser illumination arrays (PLIAs) are mounted on opposite sides of an area (i.e. 2-dimensional) type image formation and detection module (IFDM) having a fixed focal length camera lens, a fixed focal distance and fixed field of view projected through a 3-D scanning region, so that the planar laser illumination arrays produce a plane of laser illumination which is disposed substantially coplanar with sections of the field view of the image formation and detection module while the planar laser illumination beam is automatically scanned across the 3-D scanning region during object illumination and imaging operations carried out on a bar code symbol or other graphical indicia by the PLIIM-based system.

143. A PLIIM-based system comprising:

an area image formation and detection module having a field of view (FOV) projected through a 3-D scanning region;

a pair of planar laser illumination arrays for producing first and second planar laser illumination beams; and

a pair of planar laser beam folding/sweeping mirrors for folding and sweeping the planar laser illumination beams so that the optical paths of these planar laser illumination beams are oriented in an imaging direction that is coplanar with a section of the field of view of the image formation and detection module as the planar laser illumination beams are swept through the 3-D scanning region during object illumination and imaging operations.

144. A PLIIM-based system of claim 143, wherein said linear image formation and detection module further comprises an area (2-D) array of photo-electronic detectors realized using CCD technology, and each planar laser illumination array is shown comprising an array of planar laser illumination modules (PLIMs).

145. A PLIIM-based system comprising a pair of planar illumination arrays, an area-type image formation and detection module, a pair of planar laser illumination beam sweeping mirrors, an image frame grabber, an image data buffer, an image processing computer, and a camera control computer.

146. A PLIIM system comprising:

an area image formation and detection module having a field of view (FOV);

a pair of planar laser illumination arrays for producing first and second planar laser illumination beams;
a stationary field of view folding mirror for folding and projecting the field of view through a 3-D scanning region; and
a pair of planar laser beam folding/sweeping mirrors for folding and sweeping the planar laser illumination beams so that the optical paths of these planar laser illumination beams are oriented in an imaging direction that is coplanar with a section of the field of view of the image formation and detection module as the planar laser illumination beams are swept through the 3-D scanning region during object illumination and imaging operations.

147. A PLIIM-based system comprising: a pair of planar illumination arrays;
an area-type image formation and detection module;
a movable field of view folding mirror;
a pair of planar laser illumination beam sweeping mirrors jointly or otherwise synchronously movable therewith;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

148. A presentation-type holder-under bar code symbol reading system embodying the PLIIM-based subsystem of claim 146.

149. A hand-supportable-type bar code symbol reading system embodying the PLIIM-based subsystem of claim 146.

150. A PLIIM-based system, wherein a pair of planar laser illumination arrays (PLIAs) are mounted on opposite sides of an area (i.e. 2-D) type image formation and detection (IFD) module having a fixed focal length imaging lens, a variable focal distance and a fixed field of view (FOV) projected through a 3-D scanning region, so that the planar laser illumination arrays produce a plane of laser beam illumination which is disposed substantially coplanar with sections of the field view of the image formation and detection module as the planar laser illumination beams are automatically scanned through the 3-D scanning region during object illumination and image detection operations carried out on a bar code symbol or other graphical indicia by the PLIIM-based system.

151. A PLIIM-based system comprising:
an image formation and detection module having a field of view (FOV) projected through a 3-D scanning region;
a pair of planar laser illumination arrays for producing first and second planar laser illumination beams; and

a pair of planar laser beam folding/sweeping mirrors for folding and sweeping the planar laser illumination beams so that the optical paths of these planar laser illumination beams are oriented in an imaging direction that is coplanar with a section of the field of view of the image formation and detection module as the planar laser illumination beams are swept through the 3-D scanning region during object illumination and imaging operations.

152. The PLIIM-based system of claim 151, wherein said linear image formation and detection module comprises an area (2-D) array of photo-electronic detectors realized using CCD technology, and each planar laser illumination array is shown comprising an array of planar laser illumination modules.

153. A PLIIM-based system comprises:

a pair of planar laser illumination arrays, each having a plurality of PLIMs, and each PLIM being driven by a VLD driver circuit controlled by a micro-controller programmable (by camera control computer) to generate diverse types of drive-current functions that satisfy the input power and output intensity requirements of each VLD in a real-time manner;

linear-type image formation and detection module;

field of view (FOV) folding mirror, arranged in spatial relation with the image formation and detection module;

an image frame grabber operably connected to the linear-type image formation and detection module, for accessing 1-D images (i.e. 1-D digital image data sets) therefrom and building a 2-D digital image of the object being illuminated by the planar laser illumination arrays;

an image data buffer (e.g. VRAM) for buffering 2-D images received from the image frame grabber;

an image processing computer, operably connected to the image data buffer, for carrying out image processing algorithms (including bar code symbol decoding algorithms) and operators on digital images stored within the image data buffer, including image-based bar code symbol decoding software, and

a camera control computer operably connected to the various components within the system for controlling the operation thereof in an orchestrated manner.

154. The PLIIM-based system of claim 153, wherein a focused laser beam from the focusing lens is directed on the input side of the cylindrical lens element, and a planar laser illumination beam is produced as output therefrom.

155. A planar laser illumination and imaging module (PLIIM) realized on a semiconductor chip. comprising a pair of micro-sized (diffractive or refractive) cylindrical lens arrays mounted upon a pair of large linear arrays of surface emitting lasers (SELs) fabricated on opposite sides of a linear CCD image detection array.

156. A PLIIM-based semiconductor chip comprising:

a pair of linear SEL arrays for producing a composite planar laser illumination beam;

a linear CCD image detection array having field of view (FOV) arranged in a coplanar relationship with said composite planar laser illumination beam, wherein said linear CCD image detection array and said pair of linear SEL arrays are each formed a common semiconductor substrate so that said linear CCD image detection array is arranged between said pair of linear SEL arrays; and

an integrated circuit package encasing said linear CCD image detection array and said pair of linear SEL arrays, said integrated circuit package having

electrical connector pins for connected to a host system,

first and second elongated light transmission windows disposed over said pair of linear SEL arrays so that said composite planar laser illumination beam , and

a third light transmission window disposed over said linear CCD image detection array.

157. A PLIIM-based semiconductor chip mounted on a mechanically oscillating scanning element in order to sweep both the FOV of a linear image detection array and coplanar planar laser illumination beam (PLIB) through a 3-D volume of space in which objects bearing bar code and other machine-readable indicia may pass.

158. A PLIIM-based semiconductor chip comprising a plurality of linear SEL arrays which are electronically-activated to electro-optically scan (i.e. illuminate) the entire 3-D FOV of a CCD image detection array without using mechanical scanning mechanisms.

159. A PLIIM-based semiconductor chip comprising:

a miniature 2-D camera having a 2-D array of SEL diodes arranged about a centrally located 2-D area-type CCD image detection array, said 2-D array of SEL diodes and 2-D area-type CCD image detection array are both mounted on a semiconductor substrate;

a IC package for encapsulating said 2-D array of SEL diodes and said 2-D area-type CCD image detection array, and having

a centrally-located light transmission window positioned over said 2-D area-type CCD image detection array, and

a peripheral light transmission window positioned over said 2-D array of SEL diodes surrounding said centrally located 2-D area-type CCD image detection array.

160. The PLIIM-based semiconductor chip of claim 159, wherein a light focusing lens element is aligned with and mounted over said centrally-located light transmission window to define a 3-D field of view (FOV) for forming images on said 2-D area-type CCD image detection array, whereas a 2-D array of cylindrical lens elements is aligned with and mounted over said peripheral light transmission window to substantially planarize laser emission from said linear SEL arrays (comprising the 2-D SEL array) during operation.

161. The PLIIM-based semiconductor chip of claim 160, wherein each cylindrical lens element is spatially aligned with a row (or column) in said 2-D area-type CCD image detection array, and each linear array of SELs in said 2-D array of SEL diodes, over which a cylindrical lens element is mounted, is electrically addressable (i.e. activatable) by laser diode control and drive circuits.

162. The PLIIM-based semiconductor chip of claim 161, wherein said laser diode control and drive circuits are fabricated on said semiconductor substrate.

163. The PLIIM-based semiconductor chip of claim 159, wherein said 2-D area-type CCD image detection array has a 3-D field of view (FOV), and said 2-D array of SEL diodes enables the illumination of an object residing within said 3D FOV during illumination operations, and the formation of an image strip on the corresponding rows (or columns) of detector elements in said 2-D area-type CCD image detection array.

164. A method of fabricating a planar laser illumination and imaging module (PLIIM) comprising the steps of:

mounting a pair of micro-sized cylindrical lens arrays upon a pair of linear arrays of surface emitting lasers (SELs) formed between a linear CCD image detection array on a common semiconductor substrate.

165. A planar laser illumination and imaging module (PLIIM) realized on a semiconductor chip, comprising:
a linear CCD image detection array having image formation optics providing a field of view (FOV);
a pair of micro-sized cylindrical lens arrays mounted upon a pair of linear arrays of surface emitting lasers (SELs) fabricated on opposite sides of said linear CCD image detection array, so as to produce a composite planar laser illumination beam (PLIB) which is aligned with said FOV in a coplanar manner;
said linear CCD image detection array and said linear SEL arrays being formed a common semiconductor substrate, and encased within an integrated circuit (IC) package having electrical connector pins for establishing interconnections with a host system; and
first and second elongated light transmission windows disposed over said pair of linear arrays of SELs; and
a third light transmission window disposed over said linear CCD image detection array.

166. The PLIIM-based chip of claim 165, wherein said micro-sized cylindrical lens arrays are fabricated from either diffractive or refractive optical material.

167. The PLIIM of claim 165, wherein said pair of linear arrays of SELs and said linear CCD image detection array are arranged in optical isolation of each other to avoid light leaking onto said linear CCD image detector from within said IC package.

168. The PLIIM-based chip of claim 165, mounted on a mechanically oscillating scanning element in order to sweep both said FOV and coplanar PLIB through a 3-D volume of space in which objects bearing bar code and/or other machine-readable indicia or graphical intelligence may pass.

169. A planar laser illumination and imaging module (PLIIM) fabricated by forming a 2-D array of surface emitting lasers (SELs) about a 2-D area-type CCD image detection array on a common semiconductor substrate, with a field of view defining lens element mounted over the 2-D CCD image detection array and a 2-D array of cylindrical lens elements mounted over the 2-D array of SELs.

170. A bioptical PLIIM-based product identification, dimensioning and analysis (PIDA) system comprising a pair of PLIIM-based package identification systems arranged within a compact POS housing having bottom and side light transmission apertures, located beneath a pair of spatially- isolated imaging windows.

171. A bioptical PLIIM-based system for capturing and analyzing color images of products and produce items, and thus enabling, in supermarket environments, recognition of produce on the basis of color, dimensions and geometrical form.

172. A bioptical system which comprises:
a housing having bottom portion and side portion;
bottom and side light transmission apertures formed in bottom and side portions, respectively;
a first imaging window mounted over said first light transmission aperture, and a second light transmission aperture mounted over said second light transmission aperture;
a bottom PLIIM-based subsystem mounted within said bottom portion of the housing, and producing and projecting a first planar coplanar laser illumination beam (PLIB)/field of view (FOV) through said first light transmission aperture and said first imaging window;
a side PLIIM-based subsystem mounted within said side portion of the housing, and producing and projecting a second planar coplanar laser illumination beam (PLIB)/field of view (FOV) through said second light transmission aperture and said second imaging window;
an electronic product weight scale mounted beneath said bottom PLIIM-based subsystem; and
a local data communication network mounted within the housing, and establishing a high-speed data communication link between said bottom and side PLIIM-based subsystems and said electronic weight scale.

173. The bioptical PLIIM-based system of claim 172, wherein each PLIIM-based subsystem comprises:

a plurality of visible laser diodes (VLDs) having different color producing wavelengths to produce a multi-spectral planar laser illumination beam (PLIB) from the side and bottom imaging windows; and
a 1-D (linear-type) CCD image detection array for capturing color images of objects (e.g. produce) as the objects are manually transported past said first and second imaging windows of said bioptical PLIIM-based system, along the direction of an indicator arrow, by the user or operator of the system (e.g. retail sales clerk).

174. The bioptical PLIIM-based system of claim 172, wherein said PLIIM-based subsystem installed within said bottom portion of the housing, projects an automatically swept PLIB and a stationary 3-D FOV through said bottom light transmission window.

175. The bioptical PLIIM-based system of claim 172, wherein each PLIIM-based subsystem comprises:
a plurality of visible laser diodes (VLDs) having different color producing wavelengths to produce a multi-spectral planar laser illumination beam (PLIB) from said side and bottom imaging windows; and
a 2-D (area-type) CCD image detection array for capturing color images of objects (e.g. produce) as the objects are presented to the imaging windows of the bioptical system by the user or operator of the system (e.g. retail sales clerk).

176. A bioptical PLIIM-based product dimensioning, analysis and identification system comprising:
a housing having bottom portion and side portion;
bottom and side light transmission apertures formed in bottom and side portions, respectively;
a first imaging window mounted over said first light transmission aperture, and a second light transmission aperture mounted over said second light transmission aperture;
a bottom PLIIM-based subsystem mounted within said bottom portion of the housing, and employing (i) a first linear array visible laser diodes (VLDs) having different color producing wavelengths so as to produce and project a first multi-spectral planar laser illumination beam (PLIB through said first light transmission aperture and said first imaging window, and (ii) a first 1-D (linear-type) CCD image detection array having image formation optics with a first field of view (FOV) that is aligned with said first PLIB in a coplanar relationship so as to capture images of products being moved past said first imaging window; and
a side PLIIM-based subsystem mounted within said side portion of the housing, and employing a second linear array of visible laser diodes (VLDs) having different color producing wavelengths so as to produce and project a second multi-spectral planar laser illumination beam (PLIB) through said second light transmission aperture and said second imaging window, and a second 1-D (linear-type) CCD image detection array having image formation optics with a second field of view (FOV) that is aligned with said second PLIB in a coplanar relationship so as to capture images of objects products being moved past said second imaging window.

177. A bioptical PLIIM-based product dimensioning, analysis and identification system comprising:

a housing having bottom portion and side portion;
bottom and side light transmission apertures formed in bottom and side portions, respectively;
a first imaging window mounted over said first light transmission aperture, and a second light transmission aperture mounted over said second light transmission aperture;
a bottom PLIIM-based subsystem mounted within said bottom portion of the housing, and employing (i) a first linear array visible laser diodes (VLDs) having different color producing wavelengths so as to produce and project a first multi-spectral planar laser illumination beam (PLIB) through said first light transmission aperture and said first imaging window, and (ii) a first 2-D (area-type) CCD image detection array having image formation optics with a first 3-D field of view (FOV), through which said first PLIB is automatically swept in a coplanar relationship with at least a portion of said first 3-D FOV so as to capture images of products being moved past said first imaging window; and
a side PLIIM-based subsystem mounted within said side portion of the housing, and employing (i) a second linear array visible laser diodes (VLDs) having different color producing wavelengths so as to produce and project a second multi-spectral planar laser illumination beam (PLIB) through said second light transmission aperture and said second imaging window, and (ii) a second 2-D (area-type) CCD image detection array having image formation optics with a second 3-D field of view (FOV), through which said first PLIB is automatically swept in a coplanar relationship with at least a portion of said 3-D FOV so as to capture images of products being moved past said first imaging window.

178. A bioptical-type planar laser illumination and imaging (PLIIM) system for identifying products in retail environments by capturing images of said products and processing said images to recognized the identity of said products, and recognizing the shape, texture and/or color of articles of produce using one or more composite multi-spectral planar laser illumination beam (PLIBs) containing a spectrum of different characteristic wavelengths, to impart multi-color illumination characteristics thereto.

179. A bioptical-type PLIIM-based system, wherein a planar laser illumination array (PLIA) comprising a plurality of visible laser diodes (VLDs) which intrinsically exhibit high "mode-hopping" spectral characteristics which cooperate on the time domain to reduce the temporal coherence of the laser illumination sources operating in the PLIA, and thereby reduce the speckle-noise pattern observed at the image detection array of the PLIIM-based system.

180. A bioptical PLIIM-based product dimensioning, analysis and identification system comprising a pair of PLIIM-based object identification and attribute acquisition subsystems,
wherein each PLIIM-based object identification and attribute acquisition subsystem produces a multi-spectral planar laser illumination beam (PLIB) for illuminating objects during imaging, and employs a 1-D CCD image detection array with image formation optics having a field of view (FOV) that is coplanar with said PLIB; and
wherein said PLIIM-based object identification and attribute acquisition subsystem is programmed to analyze captured images of objects and determine the shape/geometry, dimensions and/or color thereof.

181. A bioptical PLIIM-based product dimensioning, analysis and identification system comprising a pair of PLIIM-based object identification and attribute acquisition subsystems,
wherein each PLIIM-based object identification and attribute acquisition subsystem produces a multi-spectral planar laser illumination beam (PLIB) for illuminating objects during imaging, and employs a 2-D (area-type) CCD image detection array with image formation optics having a field of view (FOV), through which said PLIB is automatically swept in a coplanar relationship during illumination and imaging operations; and
wherein said PLIIM-based object identification and attribute acquisition subsystem is programmed to analyze captured images of objects and determine the shape/geometry, dimensions and/or color thereof.

182. A bioptical PLIIM-based product dimensioning, analysis and identification system comprising a pair of PLIIM-based package identification and dimensioning subsystems, wherein each subsystem employs a 2-D CCD image detection array and is programmed to analyze captured images of objects and determine the shape/geometry, dimensions and/or color thereof.

183. A PLIIM-based hand-supportable linear imager comprising:
a hand-supportable housing having a light transmission window; and
a PLIIM-based image capture and processing engine including
(1) a 1-D (i.e. linear) image formation and detection module mounted within said hand-supportable housing and having a linear image detection array and an image formation optics with a field of view (FOV) projected through said light transmission window into an illumination and imaging field external to said hand-supportable housing,
(2) a pair of planar laser illumination arrays (PLIAs) mounted within said hand-supportable housing and arranged on opposite sides of said linear image detection array, each said PLIA comprising a plurality of planar laser illumination modules (PLIMs), for producing a plurality of spatially-incoherent planar laser illumination beam (PLIB) components, each arranged in a coplanar relationship with a portion of said FOV, and
(3) an optical element mounted within said hand-supportable housing, for optically combining and projecting said plurality of spatially-incoherent PLIB components through said light transmission window in coplanar relationship with said FOV, onto the same points on the surface of an object to be illuminated,
whereby said linear image detection array detects time-varying speckle-noise patterns produced by said spatially-incoherent PLIB components reflected/scattered off the illuminated object, and said time-varying speckle-noise patterns are time-averaged at said linear image detection array during the photo-integration time period thereof so as to reduce the RMS power of speckle-pattern noise observable at said linear image detection array.

184. The PLIIM-based hand-supportable linear imager of claim 183, which further comprises:

a LCD display panel integrated with said hand-supportable housing, for displaying images captured by said engine and information provided by a host computer system or other information supplying device; and

a manual data entry keypad integrated with said hand-supportable housing, for manually entering data into the imager during diverse types of information-related transactions supported by said PLIIM-based hand-supportable linear imager.

185. A manually-activated PLIIM-based hand-supportable linear imager comprising:

a hand-supportable housing having a light transmission window; and

a PLIIM-based image capture and processing engine including

(1) a 1-D (i.e. linear) image formation and detection module mounted within said hand-supportable housing and having a linear image detection array and fixed focal length/fixed focal distance image formation optics with a fixed field of view (FOV) projected through said light transmission window into an illumination and imaging field defined external to said hand-supportable housing,

(2) a pair of planar laser illumination arrays (PLIAs) mounted within said hand-supportable housing and arranged on opposite sides of said linear image detection array, each said PLIA comprising a plurality of planar laser illumination modules (PLIMs), for producing a plurality of spatially-incoherent planar laser illumination beam (PLIB) components, each being arranged in a coplanar relationship with a portion of said FOV, and

(3) an optical element mounted within said hand-supportable housing, for optically combining and projecting said plurality of spatially-incoherent PLIB components through said light transmission window in a coplanar relationship with said FOV, onto the same points on the surface of an object to be illuminated so that each said point is illuminated by a group of said plurality of spatially-incoherent PLIB components,

whereby said linear image detection array detects linear images containing time-varying speckle-noise patterns produced by said spatially-incoherent PLIB components reflected/scattered off the illuminated object, and said time-varying speckle-noise patterns are time-averaged at said linear image detection array during the photo-integration time period thereof so as to reduce the RMS power of speckle-pattern noise observable at said linear image detection array;

an image frame grabber for grabbing said linear images detected by said linear detection array;

an image data buffer for buffering said grabbed linear images and forming a 2-D image of said illuminated object;

an image processing computer for processing said 2-D image;

a camera control computer for controlling components said manually-activated PLIIM-based hand-supportable linear imager;

a manually-actuated trigger switch for manually activating the planar laser illumination arrays (driven by a set of driver circuits), said linear-type image formation and detection (IFD) module, said image frame grabber, said image data buffer, and said image processing computer, via said camera control computer, upon manual activation of said manually-actuated trigger switch, and capturing images of objects (i.e.

bearing bar code symbols and other graphical indicia) through said fixed focal length/fixed focal distance image formation optics.

186. The manually-activated PLIIM-based hand-supportable linear imager of claim 185, which further comprises:
a LCD display panel and a data entry keypad integrated with said hand-supportable housing, for supporting diverse types of transactions using said PLIIM-based hand-supportable imager.

187. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array and fixed focal length/fixed focal distance image formation optics with a fixed field of view (FOV);
(ii) an IR-based object detection subsystem within a hand-supportable housing for automatically activating upon detection of an object in its IR-based object detection field, the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

188. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array and fixed focal length/fixed focal distance image formation optics with a fixed field of view (FOV);
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays into a full-power mode of operation, the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

189. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/fixed focal distance image formation optics;

(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

190. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/fixed focal distance image formation optics;

(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the image processing computer for decode-processing upon automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

191. A manually-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;

(ii) a manually-actuated trigger switch for manually activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and

(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

192. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating upon detection of an object in its IR-based object detection field, the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

193. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays into a full-power mode of operation, the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object in its laser-based object detection field,;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

194. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module; and
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame.

195. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the image processing computer for decode-processing upon automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

196. A manually-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

197. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating upon detection of an object in its IR-based object detection field, the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

198. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays into a full-power mode of operation, the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

199. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

200. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the image processing computer for decode-processing upon automatic detection

of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

201. A PLIIM-based image capture and processing engines with linear image detection array having vertically-elongated image detection elements and an integrated despeckling mechanism.

202. A PLIIM-based image capture and processing engine for use in a hand-supportable imager, comprising:
a hand-supportable housing having a light transmission window; and
a PLIIM-based image capture and processing engine including
(1) a 2-D (i.e. area) image formation and detection module mounted within said hand-supportable housing and having a linear image detection array and an image formation optics with a field of view (FOV) projected through said light transmission window into an illumination and imaging field external to said hand-supportable housing,
(2) a pair of planar laser illumination arrays (PLIAs) mounted within said hand-supportable housing and arranged on opposite sides of said linear image detection array, each said PLIA comprising a plurality of planar laser illumination modules (PLIMs), for producing a plurality of spatially-incoherent planar laser illumination beam (PLIB) components, each arranged in a coplanar relationship with a portion of said FOV, and
(3) an optical element mounted within said hand-supportable housing, for optically combining and projecting said plurality of spatially-incoherent PLIB components through said light transmission window in coplanar relationship with said FOV, onto the same points on the surface of an object to be illuminated,
whereby said linear image detection array detects time-varying speckle-noise patterns produced by said spatially-incoherent PLIB components reflected/scattered off the illuminated object, and said time-varying speckle-noise patterns are time-averaged at said linear image detection array during the photo-integration time period thereof so as to reduce the RMS power of speckle-pattern noise observable at said linear image detection array.

203. The PLIIM-based hand-supportable linear imager of claim 202, which further comprises:
a LCD display panel integrated with said hand-supportable housing, for displaying images captured by said engine and information provided by a host computer system or other information supplying device; and

a manual data entry keypad integrated with said hand-supportable housing, for manually entering data into the imager during diverse types of information-related transactions supported by said PLIIM-based hand-supportable linear imager.

204. A manually-activated PLIIM-based hand-supportable linear imager comprising:
a hand-supportable housing having a light transmission window; and

a PLIIM-based image capture and processing engine including

(1) a 2-D (i.e. area) image formation and detection module mounted within said hand-supportable housing and having a linear image detection array and fixed focal length/fixed focal distance image formation optics with a fixed field of view (FOV) projected through said light transmission window into an illumination and imaging field defined external to said hand-supportable housing,

(2) a pair of planar laser illumination arrays (PLIAs) mounted within said hand-supportable housing and arranged on opposite sides of said linear image detection array, each said PLIA comprising a plurality of planar laser illumination modules (PLIMs), for producing a plurality of spatially-incoherent planar laser illumination beam (PLIB) components, each being arranged in a coplanar relationship with a portion of said FOV, and

(3) an optical element mounted within said hand-supportable housing, for optically combining and projecting said plurality of spatially-incoherent PLIB components through said light transmission window in a coplanar relationship with said FOV, onto the same points on the surface of an object to be illuminated so that each said point is illuminated by a group of said plurality of spatially-incoherent PLIB components,

whereby said linear image detection array detects linear images containing time-varying speckle-noise patterns produced by said spatially-incoherent PLIB components reflected/scattered off the illuminated object, and said time-varying speckle-noise patterns are time-averaged at said linear image detection array during the photo-integration time period thereof so as to reduce the RMS power of speckle-pattern noise observable at said linear image detection array;

an image frame grabber for grabbing said linear images detected by said linear detection array;

an image data buffer for buffering said grabbed linear images and forming a 2-D image of said illuminated object;

an image processing computer for processing said 2-D image;

a camera control computer for controlling components said manually-activated PLIIM-based hand-supportable linear imager;

a manually-actuated trigger switch for manually activating the planar laser illumination arrays (driven by a set of driver circuits), said linear-type image formation and detection (IFD) module, said image frame grabber, said image data buffer, and said image processing computer, via said camera control computer, upon manual activation of said manually-actuated trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through said fixed focal length/fixed focal distance image formation optics.

205. The manually-activated PLIIM-based hand-supportable linear imager of claim 204, which further comprises:
a LCD display panel and a data entry keypad integrated with said hand-supportable housing, for supporting diverse types of transactions using said PLIIM-based hand-supportable imager.

206. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA, and a 2-D (area-type) image detection array configured within an optical assembly that employs a micro-oscillating cylindrical lens array which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

207. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and an area image detection array configured within an optical assembly which employs a micro-oscillating light reflective element that provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

208. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs an acousto-electric Bragg cell structure which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

209. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a high spatial-resolution piezo-electric driven deformable mirror (DM) structure which provides a despeckling mechanism that operates in accordance with the first generalized

method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

210. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a spatial-only liquid crystal display (PO-LCD) type spatial phase modulation panel which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

211. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a visible mode locked laser diode (MLLD) which provides a despeckling mechanism that operates in accordance with the second generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

212. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs an electrically-passive optically-reflective cavity (i.e. etalon) which provides a despeckling mechanism that operates in accordance with the third method generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

213. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a pair of micro-oscillating spatial intensity modulation panels which

provide a despeckling mechanism that operates in accordance with the fifth method generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

214. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a electro-optical or mechanically rotating aperture (i.e. iris) disposed before the entrance pupil of the IFD module, which provides a despeckling mechanism that operates in accordance with the sixth method generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

215. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a high-speed electro-optical shutter disposed before the entrance pupil of the IFD module, which provides a despeckling mechanism that operates in accordance with the seventh generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

216. A manually-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type (i.e. 1D) image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV),
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to producing a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon response to the manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

217. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating upon detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

218. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

219. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

220. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);

(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the image processing computer for decode-processing in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

221. A manually-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear -type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of view (FOV);

(ii) a manually-actuated trigger switch for manually activating the planar laser illumination (to produce a planar laser illumination beam (PLIB) in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and

(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

222. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of view (FOV);

(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating in response to the detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

223. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of view (FOV);
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the a linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to the decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

224. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of FOV;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module; and
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame.

225. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear -type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of view (FOV);
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the image processing computer for decode-processing in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

226. A manually-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a field of FOV;
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

227. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a field of view (FOV);
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating in response to the detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

228. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics and a field of view;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

229. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a field of view (FOV);

(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV) the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

230. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a field of view (FOV);

(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV) the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, the image processing computer for decode-processing in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame, and (iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

231. A manually-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type (i.e. 2D) image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of field of view (FOV);

(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and

(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

232. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a FOV;
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating in response to the detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

233. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a FOV;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

234. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) a area-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a FOV;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

235. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a FOV,;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the image processing computer for decode-processing upon automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

236. A manually-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

237. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating, in response to the detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

238. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via, the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

239. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module; and
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame.

240. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer for decode-processing of image data in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

241. A manually-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

242. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating in response to the detection of an object in its IR-based object detection field, the planar laser illumination arrays (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

243. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

244. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to the decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

245. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer for decode-processing of image data in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

246. A PLIIM-based linear imager, wherein speckle-pattern noise is reduced by employing optically-combined planar laser illumination beams (PLIB) components produced from a multiplicity of spatially-incoherent laser diode sources.

247. A PLIIM-based hand-supportable linear imager, wherein a multiplicity of spatially-incoherent laser diode sources are optically combined using a cylindrical lens array and projected onto an object being illuminated, so as to achieve a greater the reduction in RMS power of observed speckle-pattern noise within the PLIIM-based linear imager.

248. A hand-supportable PLIIM-based linear imager, wherein a pair of planar laser illumination arrays (PLIAs) are mounted within its hand-supportable housing and arranged on opposite sides of a linear

image detection array mounted therein having a field of view (FOV), and wherein each PLIA comprises a plurality of planar laser illumination modules (PLIMs), for producing a plurality of spatially-incoherent planar laser illumination beam (PLIB) components.

249. A hand-supportable PLIIM-based linear imager, wherein each spatially-incoherent PLIB component is arranged in a coplanar relationship with a portion of the FOV of the linear image detection array, and an optical element (e.g. cylindrical lens array) is mounted within the hand-supportable housing, for optically combining and projecting the plurality of spatially-incoherent PLIB components through its light transmission window in coplanar relationship with the FOV, and onto the same points on the surface of an object to be illuminated.

250. A hand-supportable PLIIM-based linear imager, wherein by virtue of such operations, the linear image detection array detects time-varying speckle-noise patterns produced by the spatially-incoherent PLIB components reflected/scattered off the illuminated object, and the time-varying speckle-noise patterns are time-averaged at the linear image detection array during the photo-integration time period thereof so as to reduce the RMS power of speckle-pattern noise observable at the linear image detection array.

251. A PLIIM which embodies an optical technique that effectively destroys the spatial and/or temporal coherence of the laser illumination sources that are used to generate planar laser illumination beams (PLIBs) within PLIIM-based systems.

252. A PLIIM, wherein the spatial coherence of the illumination sources is destroyed by creating multiple "virtual" illumination sources that illuminate the object at different angles, over the photo-integration time period of the electronic image detection array used in the IFD module.

253. A PLIIM which embodies an optical technique that effectively reduces speckle-noise pattern at an image detection array by destroying the spatial and/or temporal coherence of the laser illumination sources are used to generate planar laser illumination beams (PLIBs) within the PLIIM-based system.

254. A PLIIM, wherein the spatial coherence of the illumination sources is destroyed by creating multiple "virtual" illumination sources that illuminate the object at different points in space, over the photo-integration time period of the electronic image detection array used in the system.

255. A planar laser illumination and imaging (PLIIM) system which employs high-resolution wavefront control methods and devices to reduce the power of speckle-noise patterns within digital images acquired by the system.

256. A PLIIM-based system, in which planar laser illumination beams (PLIBs) rich in spectral-harmonic components on the time-frequency domain are optically generated using principles based on wavefront spatio-temporal dynamics.

257. A PLIIM-based system, in which planar laser illumination beams (PLIBs) rich in spectral-harmonic components on the time-frequency domain are optically generated using principles based on wavefront non-linear dynamics.

258. A PLIIM-based system, in which planar laser illumination beams (PLIBs) rich in spectral-harmonic components on the spatial-frequency domain are optically generated using principles based on wavefront spatio-temporal dynamics.

259. A PLIIM-based system, in which planar laser illumination beams (PLIBs) rich in spectral-harmonic components on the spatial-frequency domain are optically generated using principles based on wavefront non-linear dynamics.

260. A PLIIM-based system, in which planar laser illumination beams (PLIBs) rich in spectral-harmonic components are optically generated using diverse electro-optical devices selected from the group consisting of micro-electro-mechanical devices (MEMs) (e.g. deformable micro-mirrors), optically-addressed liquid crystal (LC) light valves, liquid crystal (LC) phase modulators, micro-oscillating reflectors (e.g. mirrors or spectrally-tuned polarizing reflective CLC film material), micro-oscillating refractive-type phase modulators, micro-oscillating diffractive-type micro-oscillators, as well as rotating phase modulation discs, bands, rings and the like.

261. A planar laser illumination and imaging (PLIIM) system and method which employs a planar laser illumination array (PLIA) and electronic image detection array which cooperate to effectively reduce the speckle-noise pattern observed at the image detection array of the PLIIM system by reducing or destroying either (i) the spatial and/or temporal coherence of the planar laser illumination beams (PLIBs) produced by the PLIAs within the PLIIM system, or (ii) the spatial and/or temporal coherence of the planar laser illumination beams (PLIBs) that are reflected/scattered off the target and received by the image formation and detection (IFD) subsystem within the PLIIM system.

262. A planar laser illumination and imaging (PLIIM) system comprising: a planar laser illumination array (PLIA) and electronic image detection array which cooperate to effectively reduce the speckle-noise pattern observed at the image detection array of the PLIIM system by reducing or destroying either (i) the spatial and/or temporal coherence of the planar laser illumination beams (PLIBs) produced by the PLIAs within the PLIIM system, or (ii) the spatial and/or temporal coherence of the planar laser illumination beams (PLIBs) that are reflected/scattered off the target and received by the image formation and detection (IFD) subsystem within the PLIIM system.

263. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method is based on temporal intensity modulating the composite-type return PLIB produced by the composite PLIB illuminating and reflecting and scattering off an object so that the return composite PLIB detected by the image detection array in the IFD subsystem constitutes a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are detected over the photo-integration time period of the image detection array, thereby allowing these time-varying speckle-noise patterns to be temporally and spatially averaged and the RMS power of observed speckle-noise patterns reduced.

264. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein (i) the returned laser beam produced by the transmitted PLIB illuminating and reflecting/scattering off an object is temporal-intensity modulated according to a temporal intensity modulation (e.g. windowing) function (TIMF) so as to modulate the phase along the wavefront of the composite PLIB and produce numerous substantially different time-varying speckle-noise patterns at image detection array of the IFD Subsystem, and (ii) temporally and spatially averaging the numerous time-varying speckle-noise patterns at the image detection array during the photo-integration time period thereof, thereby reducing the RMS power of the speckle-noise patterns observed at the image detection array.

265. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein temporal intensity modulation techniques which can be used to carry out the method include, for example: high-speed electro-optical (e.g. ferro-electric, LCD, etc.) shutters located before the image detector along the optical axis of the camera subsystem; and any other temporal intensity modulation element arranged before the image detector along the optical axis of the camera subsystem, and through which the received PLIB beam may pass during illumination and image detection operations.

266. A method of and apparatus for speckle-noise pattern reduction based on the principle of spatially phase modulating the transmitted planar laser illumination beam (PLIB) prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

267. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method involves modulating the

spatial phase of the composite-type "transmitted" planar laser illumination beam (PLIB) prior to illuminating an object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise pattern reduced.

268. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein (i) the spatial phase of the transmitted PLIB is modulated along the planar extent thereof according to a spatial phase modulation function (SPMF) so as to modulate the phase along the wavefront of the PLIB and produce numerous substantially different time-varying speckle-noise patterns to occur at the image detection array of the IFD Subsystem during the photo-integration time period of the image detection array thereof, and also (ii) the numerous time-varying speckle-noise patterns produced at the image detection array are temporally and/or spatially averaged during the photo-integration time period thereof, thereby reducing the speckle-noise patterns observed at the image detection array.

269. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the spatial phase modulation techniques that can be used to carry out the method include, for example: mechanisms for moving the relative position/motion of a cylindrical lens array and laser diode array, including reciprocating a pair of rectilinear cylindrical lens arrays relative to each other, as well as rotating a cylindrical lens array ring structure about each PLIM employed in the PLIIM-based system; rotating phase modulation discs having multiple sectors with different refractive indices to effect different degrees of phase delay along the wavefront of the PLIB transmitted (along different optical paths) towards the object to be illuminated; acousto-optical Bragg-type cells for enabling beam steering using ultrasonic waves; ultrasonically-driven deformable mirror structures; a LCD-type spatial phase modulation panel; and other spatial phase modulation devices.

270. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the transmitted planar laser illumination beam (PLIB) is spatially phase modulated along the planar extent thereof according to a (random or periodic) spatial phase modulation function (SPMF) prior to illumination of the target object with the PLIB, so as to modulate the phase along the wavefront of the PLIB and produce numerous substantially different time-varying speckle-noise pattern at the image detection array, and temporally and spatially average these speckle-noise patterns at the image detection array during the photo-integration time period thereof to reduce the RMS power of observable speckle-pattern noise.

272. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the spatial phase modulation techniques that can be used to carry out the method of despeckling include, for example: mechanisms for moving the relative position/motion of a cylindrical lens array and laser diode array, including reciprocating a pair of rectilinear cylindrical lens arrays relative to each other, as well as rotating a cylindrical lens array ring structure about each PLIM employed in the PLIIM-based system; rotating phase modulation discs having multiple sectors with different refractive indices to effect different degrees of phase delay along the wavefront of the PLIB transmitted (along different optical paths) towards the object to be illuminated; acousto-optical Bragg-type cells for enabling beam steering using ultrasonic waves; ultrasonically-driven deformable mirror structures; a LCD-type spatial phase modulation panel; and other spatial phase modulation devices.

273. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein a pair of refractive cylindrical lens arrays are micro-oscillated relative to each other in order to spatial phase modulate the planar laser illumination beam prior to target object illumination.

274. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein a pair of light diffractive (e.g. holographic) cylindrical lens arrays are micro-oscillated relative to each other in order to spatial phase modulate the planar laser illumination beam prior to target object illumination.

275. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein a pair of reflective elements are micro-oscillated relative to a stationary refractive cylindrical lens array in order to spatial phase modulate a planar laser illumination beam prior to target object illumination.

276. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination (PLIB) is micro-oscillated using an acoustic-optic modulator in order to spatial phase modulate the PLIB prior to target object illumination.

277. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination (PLIB) is micro-oscillated using a piezo-electric driven deformable mirror structure in order to spatial phase modulate said PLIB prior to target object illumination.

278. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination (PLIB) is

micro-oscillated using a refractive-type phase-modulation disc in order to spatial phase modulate said PLIB prior to target object illumination.

279. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination (PLIB) is micro-oscillated using a phase-only type LCD-based phase modulation panel in order to spatial phase modulate said PLIB prior to target object illumination.

280. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination (PLIB) is micro-oscillated using a refractive-type cylindrical lens array ring structure in order to spatial phase modulate said PLIB prior to target object illumination.

281. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination (PLIB) is micro-oscillated using a diffractive-type cylindrical lens array ring structure in order to spatial intensity modulate said PLIB prior to target object illumination.

282. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination (PLIB) is micro-oscillated using a reflective-type phase modulation disc structure in order to spatial phase modulate said PLIB prior to target object illumination.

283. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein a planar laser illumination (PLIB) is micro-oscillated using a rotating polygon lens structure which spatial phase modulates said PLIB prior to target object illumination.

284. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on reducing the temporal coherence of the planar laser illumination beam before it illuminates the target object by applying temporal intensity modulation techniques during the transmission of the PLIB towards the target.

285. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on the principle of temporal intensity modulating the transmitted planar laser illumination beam (PLIB) prior to illuminating a target object (e.g, package) therewith so that the object is illuminated with a spatially coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem),

thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

286. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method involves modulating the temporal intensity of the composite-type "transmitted" planar laser illumination beam (PLIB) prior to illuminating an object (e.g. package) therewith so that the object is illuminated with a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise pattern reduced.

287. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the transmitted planar laser illumination beam (PLIB) is temporal intensity modulated prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a temporally coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise patterns reduced.

288. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on temporal intensity modulating the transmitted PLIB prior to illuminating an object therewith so that the object is illuminated with a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced at the image detection array in the IFD subsystem over the photo-integration time period thereof, and the numerous time-varying speckle-noise patterns are temporally and/or spatially averaged during the photo-integration time period, thereby reducing the RMS power of speckle-noise pattern observed at the image detection array.

289. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein (i) the transmitted PLIB is temporal-intensity modulated according to a temporal intensity modulation (e.g. windowing) function (TIMF) causing the phase along the wavefront of the transmitted PLIB to be modulated and numerous substantially different time-varying speckle-noise patterns produced at image detection array of the IFD subsystem, and (ii) the numerous time-varying speckle-noise patterns produced at the image detection array are temporally and/or spatially averaged during the photo-integration time period thereof, thereby reducing the RMS power of RMS speckle-noise patterns observed (i.e. detected) at the image detection array.

290. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein temporal intensity modulation techniques which can be used to carry out the method include, for example: visible mode-locked laser diodes (MLLDs) employed in the planar laser illumination array; electro-optical temporal intensity modulation panels (i.e. shutters) disposed along the optical path of the transmitted PLIB; and other temporal intensity modulation devices.

291. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein temporal intensity modulation techniques which can be used to carry out the first generalized method include, for example: mode-locked laser diodes (MLLDs) employed in a planar laser illumination array; electrically-passive optically-reflective cavities affixed external to the VLD of a planar laser illumination module (PLIM; electro-optical temporal intensity modulators disposed along the optical path of a composite planar laser illumination beam; laser beam frequency-hopping devices; internal and external type laser beam frequency modulation (FM) devices; and internal and external laser beam amplitude modulation (AM) devices.

292. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination beam is temporal intensity modulated prior to target object illumination employing high-speed beam gating/shutter principles.

293. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination beam is temporal intensity modulated prior to target object illumination employing visible mode-locked laser diodes (MLLDs).

294. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination beam is temporal intensity modulated prior to target object illumination employing current-modulated visible laser diodes (VLDs) operated in accordance with temporal intensity modulation functions (TIMFS) which exhibit a spectral harmonic constitution that results in a substantial reduction in the RMS power of speckle-pattern noise observed at the image detection array of PLIIM-based systems.

295. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on reducing the temporal-coherence of the planar laser illumination beam before it illuminates the target object by applying temporal phase modulation techniques during the transmission of the PLIB towards the target.

296. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on the principle of temporal phase modulating the transmitted planar laser illumination beam (PLIB) prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a temporal coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

297. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method involves modulating the temporal phase of the composite-type "transmitted" planar laser illumination beam (PLIB) prior to illuminating an object (e.g. package) therewith so that the object is illuminated with a temporal coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise pattern reduced.

298. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein temporal phase modulation techniques which can be used to carry out the third generalized method include, for example: an optically-reflective cavity (i.e. etalon device) affixed to external portion of each VLD; a phase-only LCD temporal intensity modulation panel; and fiber optical arrays.

299. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination beam is temporal phase modulated prior to target object illumination employing photon trapping, delaying and releasing principles within an optically reflective cavity (i.e. etalon) externally affixed to each visible laser diode within the planar laser illumination array.

300. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination (PLIB) is temporal phase modulated using a phase-only type LCD-based phase modulation panel prior to target object illumination.

301. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination beam

(PLIB) is temporal phase modulated using a high-density fiber-optic array prior to target object illumination.

302. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on reducing the temporal coherence of the planar laser illumination beam before it illuminates the target object by applying temporal frequency modulation techniques during the transmission of the PLIB towards the target.

303. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on the principle of temporal frequency modulating the transmitted planar laser illumination beam (PLIB) prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

304. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method involves modulating the temporal frequency of the composite-type "transmitted" planar laser illumination beam (PLIB) prior to illuminating an object (e.g. package) therewith so that the object is illuminated with a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise pattern reduced.

305. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein techniques which can be used to carry out the third generalized method include, for example: junction-current control techniques for periodically inducing VLDs into a mode of frequency hopping, using thermal feedback; and multi-mode visible laser diodes (VLDs) operated just above their lasing threshold.

306. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination beam is temporal frequency modulated prior to target object illumination employing drive-current modulated visible laser diodes (VLDs) into modes of frequency hopping and the like.

307. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the planar laser illumination beam is

temporal frequency modulated prior to target object illumination employing multi-mode visible laser diodes (VLDs) operated just above their lasing threshold.

308. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the spatial intensity modulation techniques that can be used to carry out the method include, for example: mechanisms for moving the relative position/motion of a spatial intensity modulation array (e.g. screen) relative to a cylindrical lens array and/or a laser diode array, including reciprocating a pair of rectilinear spatial intensity modulation arrays relative to each other, as well as rotating a spatial intensity modulation array ring structure about each PLIM employed in the PLIIM-based system; a rotating spatial intensity modulation disc; and other spatial intensity modulation devices.

309. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on reducing the spatial-coherence of the planar laser illumination beam before it illuminates the target object by applying spatial intensity modulation techniques during the transmission of the PLIB towards the target.

310. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the wavefront of the transmitted planar laser illumination beam (PLIB) is spatially intensity modulated prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

311. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein spatial intensity modulation techniques can be used to carry out the fifth generalized method including, for example: a pair of comb-like spatial filter arrays reciprocated relative to each other at a high-speeds; rotating spatial filtering discs having multiple sectors with transmission apertures of varying dimensions and different light transmittivity to spatial intensity modulate the transmitted PLIB along its wavefront; a high-speed LCD-type spatial intensity modulation panel; and other spatial intensity modulation devices capable of modulating the spatial intensity along the planar extent of the PLIB wavefront.

312. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein a pair of spatial intensity modulation (SIM) panels are micro-oscillated with respect to the cylindrical lens array so as to spatial-intensity modulate the planar laser illumination beam (PLIB) prior to target object illumination.

313. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on reducing the spatial-coherence of the planar laser illumination beam after it illuminates the target by applying spatial intensity modulation techniques during the detection of the reflected/scattered PLIB.

314. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method is based on spatial intensity modulating the composite-type "return" PLIB produced by the composite PLIB illuminating and reflecting and scattering off an object so that the return PLIB detected by the image detection array (in the IFD subsystem) constitutes a spatially coherent-reduced laser beam and, as a result, numerous time-varying speckle-noise patterns are detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these time-varying speckle-noise patterns to be temporally and spatially-averaged and the RMS power of the observed speckle-noise patterns reduced.

315. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein (i) the return PLIB produced by the transmitted PLIB illuminating and reflecting/scattering off an object is spatial-intensity modulated (along the dimensions of the image detection elements) according to a spatial-intensity modulation function (SIMF) so as to modulate the phase along the wavefront of the composite return PLIB and produce numerous substantially different time-varying speckle-noise patterns at the image detection array in the IFD Subsystem, and also (ii) temporally and spatially average the numerous time-varying speckle-noise patterns produced at the image detection array during the photo-integration time period thereof, thereby reducing the RMS power of the speckle-noise patterns observed at the image detection array.

316. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the composite-type "return" PLIB (produced when the transmitted PLIB illuminates and reflects and/or scatters off the target object) is spatial intensity modulated, constituting a spatially coherent-reduced laser light beam and, as a result, numerous time-varying speckle-noise patterns are detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these time-varying speckle-noise patterns to be temporally and/or spatially averaged and the observable speckle-noise pattern reduced.

317. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the return planar laser illumination beam is spatial-intensity modulated prior to detection at the image detector.

318. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein spatial intensity modulation

techniques which can be used to carry out the sixth generalized method include, for example: high-speed electro-optical (e.g. ferro-electric, LCD, etc.) dynamic spatial filters, located before the image detector along the optical axis of the camera subsystem; physically rotating spatial filters, and any other spatial intensity modulation element arranged before the image detector along the optical axis of the camera subsystem, through which the received PLIB beam may pass during illumination and image detection operations for spatial intensity modulation without causing optical image distortion at the image detection array.

319. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein spatial intensity modulation techniques which can be used to carry out the method include, for example: a mechanism for physically or photo-electronically rotating a spatial intensity modulator (e.g. apertures, irises, etc.) about the optical axis of the imaging lens of the camera module; and any other axially symmetric, rotating spatial intensity modulation element arranged before the entrance pupil of the camera module, through which the received PLIB beam may enter at any angle or orientation during illumination and image detection operations.

320. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on reducing the temporal coherence of the planar laser illumination beam after it illuminates the target by applying temporal intensity modulation techniques during the detection of the reflected/scattered PLIB.

321. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the composite-type "return" PLIB (produced when the transmitted PLIB illuminates and reflects and/or scatters off the target object) is temporal intensity modulated, constituting a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these time-varying speckle-noise patterns to be temporally and/or spatially averaged and the observable speckle-noise pattern reduced. This method can be practiced with any of the PLIM-based systems of the present invention disclosed herein, as well as any system constructed in accordance with the general principles of the present invention.

322. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein temporal intensity modulation techniques which can be used to carry out the method include, for example: high-speed temporal modulators such as electro-optical shutters, pupils, and stops, located along the optical path of the composite return PLIB focused by the IFD subsystem; etc.

323. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the return planar laser illumination beam is temporal intensity modulated prior to image detection by employing high-speed light gating/switching principles.

324. A planar laser illumination and imaging module which employs a planar laser illumination array (PLIA) comprising a plurality of visible laser diodes having a plurality of different characteristic wavelengths residing within different portions of the visible band.

325. A planar laser illumination and imaging module (PLIIM), wherein the visible laser diodes within the PLIA thereof are spatially arranged so that the spectral components of each neighboring visible laser diode (VLD) spatially overlap and each portion of the composite PLIB along its planar extent contains a spectrum of different characteristic wavelengths, thereby imparting multi-color illumination characteristics to the composite PLIB.

326. A PLIIM, wherein the multi-color illumination characteristics of the composite PLIB reduce the temporal coherence of the laser illumination sources in the PLIA, thereby reducing the RMS power of the speckle-noise pattern observed at the image detection array of the PLIIM.

327. A planar laser illumination and imaging module (PLIIM) which employs a planar laser illumination array (PLIA) comprising a plurality of visible laser diodes (VLDs) which exhibit high "mode-hopping" spectral characteristics which cooperate on the time domain to reduce the temporal coherence of the laser illumination sources operating in the PLIA and produce numerous substantially different time-varying speckle-noise patterns during each photo-integration time period, thereby reducing the RMS power of the speckle-noise pattern observed at the image detection array in the PLIIM.

328. A planar laser illumination and imaging module (PLIIM) which employs a planar laser illumination array (PLIA) comprising a plurality of visible laser diodes (VLDs) which are "thermally-driven" to exhibit high "mode-hopping" spectral characteristics which cooperate on the time domain to reduce the temporal coherence of the laser illumination sources operating in the PLIA, and thereby reduce the speckle noise pattern observed at the image detection array in the PLIIM accordance with the principles of the present invention.

329. A first generalized method of speckle-noise pattern reduction and particular forms of apparatus therefor based on reducing the spatial-coherence of the planar laser illumination beam before it illuminates the target object by applying spatial phase modulation techniques during the transmission of the PLIB towards the target.

330. Another object of the present invention is to provide such a method and apparatus, based on the principle of spatially phase modulating a transmitted planar laser illumination beam (PLIB) prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

331. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method involves modulating the spatial phase of a composite-type "transmitted" planar laser illumination beam (PLIB) prior to illuminating an object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise pattern reduced.

332. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein (i) the spatial phase of a transmitted PLIB is modulated along the planar extent thereof according to a spatial phase modulation function (SPMF) so as to modulate the phase along the wavefront of the PLIB and produce numerous substantially different time-varying speckle-noise patterns to occur at the image detection array of the IFD Subsystem during the photo-integration time period of the image detection array thereof, and also (ii) the numerous time-varying speckle-noise patterns produced at the image detection array are temporally and/or spatially averaged during the photo-integration time period thereof, thereby reducing the speckle-noise patterns observed at the image detection array.

333. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the spatial phase modulation techniques that can be used to carry out the method include, for example: mechanisms for moving the relative position/motion of a cylindrical lens array and laser diode array, including reciprocating a pair of rectilinear cylindrical lens arrays relative to each other, as well as rotating a cylindrical lens array ring structure about each PLIM employed in the PLIIM-based system; rotating phase modulation discs having multiple sectors with different refractive indices to effect different degrees of phase delay along the wavefront of the PLIB transmitted (along different optical paths) towards the object to be illuminated; acousto-optical Bragg-type cells for enabling beam steering using ultrasonic waves; ultrasonically-driven deformable mirror structures; a LCD-type spatial phase modulation panel; and other spatial phase modulation devices.

334. A method and apparatus, wherein the transmitted planar laser illumination beam (PLIB) is spatially phase modulated along the planar extent thereof according to a (random or periodic) spatial phase modulation function (SPMF) prior to illumination of the target object with the PLIB, so as to modulate the phase along the wavefront of the PLIB and produce numerous substantially different time-varying speckle-noise pattern at the image detection array, and temporally and spatially average these speckle-noise patterns at the image detection array during the photo-integration time period thereof to reduce the RMS power of observable speckle-pattern noise.

335. A method and apparatus, wherein the spatial phase modulation techniques that can be used to carry out the first generalized method of despeckling include, for example: mechanisms for moving the relative position/motion of a cylindrical lens array and laser diode array, including reciprocating a pair of rectilinear cylindrical lens arrays relative to each other, as well as rotating a cylindrical lens array ring structure about each PLIM employed in the PLIIM-based system; rotating phase modulation discs having multiple sectors with different refractive indices to effect different degrees of phase delay along the wavefront of the PLIB transmitted (along different optical paths) towards the object to be illuminated; acousto-optical Bragg-type cells for enabling beam steering using ultrasonic waves; ultrasonically-driven deformable mirror structures; a LCD-type spatial phase modulation panel; and other spatial phase modulation devices.

336. A method and apparatus, wherein a pair of refractive cylindrical lens arrays are micro-oscillated relative to each other in order to spatial phase modulate the planar laser illumination beam prior to target object illumination.

337. A method and apparatus, wherein a pair of light diffractive (e.g. holographic) cylindrical lens arrays are micro-oscillated relative to each other in order to spatial phase modulate the planar laser illumination beam prior to target object illumination.

338. A method and apparatus, wherein a pair of reflective elements are micro-oscillated relative to a stationary refractive cylindrical lens array in order to spatial phase modulate a planar laser illumination beam prior to target object illumination.

339. A method and apparatus, wherein a planar laser illumination beam (PLIB) is micro-oscillated using an acoustic-optic modulator in order to spatial phase modulate the PLIB prior to target object illumination.

340. A method and apparatus, wherein a planar laser illumination beam (PLIB) is micro-oscillated using a piezo-electric driven deformable mirror structure in order to spatial phase modulate said PLIB prior to target object illumination.

341. A method and apparatus, wherein a planar laser illumination beam (PLIB) is micro-oscillated using a refractive-type phase-modulation disc in order to spatial phase modulate said PLIB prior to target object illumination.

342. A method and apparatus, wherein a planar laser illumination beam (PLIB) is micro-oscillated using a phase-only type LCD-based phase modulation panel in order to spatial phase modulate said PLIB prior to target object illumination.

343. A method and apparatus, wherein a planar laser illumination beam (PLIB) is micro-oscillated using a refractive-type cylindrical lens array ring structure in order to spatial phase modulate said PLIB prior to target object illumination

344. A method and apparatus, wherein a planar laser illumination beam (PLIB) is micro-oscillated using a diffractive-type cylindrical lens array ring structure in order to spatial intensity modulate said PLIB prior to target object illumination.

345. A method and apparatus, wherein a planar laser illumination beam (PLIB) is micro-oscillated using a reflective-type phase modulation disc structure in order to spatial phase modulate said PLIB prior to target object illumination.

346. A method and apparatus, wherein a planar laser illumination beam (PLIB) is micro-oscillated using a rotating polygon lens structure which spatial phase modulates said PLIB prior to target object illumination.

347. A second generalized method of speckle-noise pattern reduction and particular forms of apparatus therefor based on reducing the temporal coherence of a planar laser illumination beam (PLIB) before it illuminates the target object by applying temporal intensity modulation techniques during the transmission of the PLIB towards the target.

348. A method and apparatus, based on the principle of temporal intensity modulating a transmitted planar laser illumination beam (PLIB) prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

349. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method involves modulating the temporal intensity of a composite-type "transmitted" planar laser illumination beam (PLIB) prior to illuminating an object (e.g. package) therewith so that the object is illuminated with a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise pattern reduced.

350. A method and apparatus, wherein a transmitted planar laser illumination beam (PLIB) is temporal intensity modulated prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a temporally coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise patterns reduced.

351. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, based on temporal intensity modulating the transmitted PLIB prior to illuminating an object therewith so that the object is illuminated with a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced at the image detection array in the IFD subsystem over the photo-integration time period thereof, and the numerous time-varying speckle-noise patterns are temporally and/or spatially averaged during the photo-integration time period, thereby reducing the RMS power of speckle-noise pattern observed at the image detection array.

352. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein (i) the transmitted PLIB is temporal-intensity modulated according to a temporal intensity modulation (e.g. windowing) function (TIMF) causing the phase along the wavefront of the transmitted PLIB to be modulated and numerous substantially different time-varying speckle-noise patterns produced at image detection array of the IFD Subsystem, and (ii) the numerous time-varying speckle-noise patterns produced at the image detection array are temporally and/or spatially averaged during the photo-integration time period thereof, thereby reducing the RMS power of RMS speckle-noise patterns observed (i.e. detected) at the image detection array.

353. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein temporal intensity modulation techniques which can be used to carry out the method include, for example: visible mode-locked laser

diodes (MLLDs) employed in the planar laser illumination array; electro-optical temporal intensity modulation panels (i.e. shutters) disposed along the optical path of the transmitted PLIB; and other temporal intensity modulation devices.

354. A method and apparatus, wherein temporal intensity modulation techniques which can be used to carry out the first generalized method include, for example: mode-locked laser diodes (MLLDs) employed in a planar laser illumination array; electrically-passive optically-reflective cavities affixed external to the VLD of a planar laser illumination module (PLIM; electro-optical temporal intensity modulators disposed along the optical path of a composite planar laser illumination beam; laser beam frequency-hopping devices; internal and external type laser beam frequency modulation (FM) devices; and internal and external laser beam amplitude modulation (AM) devices.

355. A method and apparatus, wherein a planar laser illumination beam (PLIB) is temporal intensity modulated prior to target object illumination employing high-speed beam gating/shutter principles.

356. A method and apparatus, wherein a planar laser illumination beam (PLIB) is temporal intensity modulated prior to target object illumination employing current-modulated visible laser diodes (VLDs) operated in accordance with temporal intensity modulation functions (TIMFS) which exhibit a spectral harmonic constitution that results in a substantial reduction in the RMS power of speckle-pattern noise observed at the image detection array of PLIIM-based systems.

357. A third generalized method of speckle-noise pattern reduction and particular forms of apparatus therefor based on reducing the temporal-coherence of the planar laser illumination beam before it illuminates the target object by applying temporal phase modulation techniques during the transmission of the PLIB towards the target.

358. A method and apparatus, based on the principle of temporal phase modulating the transmitted planar laser illumination beam (PLIB) prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a temporal coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

359. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method involves modulating the temporal phase of a composite-type "transmitted" planar laser illumination beam (PLIB) prior to illuminating an object (e.g. package) therewith so that the object is illuminated with a temporal coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced

and detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise pattern reduced.

360. A method and apparatus of claim 357, wherein temporal phase modulation techniques which can be used to carry out the third generalized method include, for example: an optically-reflective cavity (i.e. etalon device) affixed to external portion of each VLD; a phase-only LCD temporal intensity modulation panel; and fiber optical arrays.

361. A method and apparatus, wherein a planar laser illumination beam (PLIB) is temporal phase modulated prior to target object illumination employing photon trapping, delaying and releasing principles within an optically reflective cavity (i.e. etalon) externally affixed to each visible laser diode within the planar laser illumination array.

362. A method and apparatus, wherein a planar laser illumination beam (PLIB) is temporal phase modulated using a phase-only type LCD-based phase modulation panel prior to target object illumination

363. A method and apparatus, wherein the planar laser illumination beam (PLIB) is temporal phase modulated using a high-density fiber-optic array prior to target object illumination.

364. A fourth generalized method of speckle-noise pattern reduction and particular forms of apparatus therefor based on reducing the temporal coherence of a planar laser illumination beam (PLIB) before it illuminates the target object by applying temporal frequency modulation techniques during the transmission of the PLIB towards the target.

365. A method and apparatus, based on the principle of temporal frequency modulating a transmitted planar laser illumination beam (PLIB) prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

366. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method involves modulating the temporal frequency of a composite-type "transmitted" planar laser illumination beam (PLIB) prior to illuminating an object (e.g. package) therewith so that the object is illuminated with a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array in the IFD

subsystem, thereby allowing these speckle-noise patterns to be temporally averaged and/or spatially averaged and the observable speckle-noise pattern reduced.

367. A method and apparatus, wherein techniques which can be used to carry out the third generalized method include, for example: junction-current control techniques for periodically inducing VLDs into a mode of frequency hopping, using thermal feedback; and multi-mode visible laser diodes (VLDs) operated just above their lasing threshold.

368. A method and apparatus, wherein the planar laser illumination beam is temporal frequency modulated prior to target object illumination employing drive-current modulated visible laser diodes (VLDs) into modes of frequency hopping and the like.

369. A method and apparatus, wherein a planar laser illumination beam (PLIB) is temporal frequency modulated prior to target object illumination employing multi-mode visible laser diodes (VLDs) operated just above their lasing threshold.

370. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the spatial intensity modulation techniques that can be used to carry out the method include, for example: mechanisms for moving the relative position/motion of a spatial intensity modulation array (e.g. screen) relative to a cylindrical lens array and/or a laser diode array, including reciprocating a pair of rectilinear spatial intensity modulation arrays relative to each other, as well as rotating a spatial intensity modulation array ring structure about each PLIM employed in the PLIIM-based system; a rotating spatial intensity modulation disc; and other spatial intensity modulation devices.

371. A fifth generalized method of speckle-noise pattern reduction and particular forms of apparatus therefor based on reducing the spatial-coherence of a planar laser illumination beam (PLIB) before it illuminates the target object by applying spatial intensity modulation techniques during the transmission of the PLIB towards the target.

372. A method and apparatus, wherein the wavefront of a transmitted planar laser illumination beam (PLIB) is spatially intensity modulated prior to illuminating a target object (e.g. package) therewith so that the object is illuminated with a spatially coherent-reduced planar laser beam and, as a result, numerous substantially different time-varying speckle-noise patterns are produced and detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these speckle-noise patterns to be temporally averaged and possibly spatially averaged over the photo-integration time period and the RMS power of observable speckle-noise pattern reduced.

373. The method and apparatus of claim 371, wherein spatial intensity modulation techniques can be used to carry out the fifth generalized method including, for example: a pair of comb-like spatial filter arrays reciprocated relative to each other at a high-speeds; rotating spatial filtering discs having multiple sectors with transmission apertures of varying dimensions and different light transmittivity to spatial intensity modulate the transmitted PLIB along its wavefront; a high-speed LCD-type spatial intensity modulation panel; and other spatial intensity modulation devices capable of modulating the spatial intensity along the planar extent of the PLIB wavefront.

374. A method and apparatus, wherein a pair of spatial intensity modulation (SIM) panels are micro-oscillated with respect to a cylindrical lens array so as to spatial-intensity modulate the planar laser illumination beam (PLIB) prior to target object illumination.

375. A sixth generalized method of speckle-noise pattern reduction and particular forms of apparatus therefor based on reducing the spatial-coherence of a planar laser illumination beam after it illuminates the target by applying spatial intensity modulation techniques during the detection of the reflected/scattered PLIB.

376. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein the method is based on spatial intensity modulating a composite-type "return" PLIB produced by a composite PLIB illuminating and reflecting and scattering off an object so that the return PLIB detected by the image detection array (in the IFD subsystem) constitutes a spatially coherent-reduced laser beam and, as a result, numerous time-varying speckle-noise patterns are detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these time-varying speckle-noise patterns to be temporally and spatially-averaged and the RMS power of the observed speckle-noise patterns reduced.

377. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein (i) a return PLIB produced by a transmitted PLIB illuminating and reflecting/scattering off an object is spatial-intensity modulated (along the dimensions of the image detection elements) according to a spatial-intensity modulation function (SIMF) so as to modulate the phase along the wavefront of the composite return PLIB and produce numerous substantially different time-varying speckle-noise patterns at the image detection array in the IFD Subsystem, and also (ii) temporally and spatially average the numerous time-varying speckle-noise patterns produced at the image detection array during the photo-integration time period thereof, thereby reducing the RMS power of the speckle-noise patterns observed at the image detection array.

378. A method and apparatus, wherein a composite-type "return" PLIB (produced when the transmitted PLIB illuminates and reflects and/or scatters off the target object) is spatial intensity modulated, constituting a spatially coherent-reduced laser light beam and, as a result, numerous time-varying

speckle-noise patterns are detected over the photo-integration time period of the image detection array in the IFD subsystem, thereby allowing these time-varying speckle-noise patterns to be temporally and/or spatially averaged and the observable speckle-noise pattern reduced.

379. A method and apparatus, wherein the return planar laser illumination beam is spatial-intensity modulated prior to detection at the image detector.

380. The method and apparatus of claim 375, wherein spatial intensity modulation techniques which can be used to carry out the sixth generalized method include, for example: high-speed electro-optical (e.g. ferro-electric, LCD, etc.) dynamic spatial filters, located before the image detector along the optical axis of the camera subsystem; physically rotating spatial filters, and any other spatial intensity modulation element arranged before the image detector along the optical axis of the camera subsystem, through which the received PLIB beam may pass during illumination and image detection operations for spatial intensity modulation without causing optical image distortion at the image detection array.

381. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, wherein spatial intensity modulation techniques which can be used to carry out the method include, for example: a mechanism for physically or photo-electronically rotating a spatial intensity modulator (e.g. apertures, irises, etc.) about the optical axis of the imaging lens of the camera module; and any other axially symmetric, rotating spatial intensity modulation element arranged before the entrance pupil of the camera module, through which the received PLIB beam may enter at any angle or orientation during illumination and image detection operations.

382. A seventh generalized method of speckle-noise pattern reduction and particular forms of apparatus therefor based on reducing the temporal coherence of a planar laser illumination beam (PLIB) after it illuminates the target by applying temporal intensity modulation techniques during the detection of the reflected/scattered PLIB.

383. A method and apparatus, wherein a composite-type "return" PLIB (produced when the transmitted PLIB illuminates and reflects and/or scatters off the target object) is temporal intensity modulated, constituting a temporally coherent-reduced laser beam and, as a result, numerous time-varying (random) speckle-noise patterns are detected over the photo-integration time period of the image detection array (in the IFD subsystem), thereby allowing these time-varying speckle-noise patterns to be temporally and/or spatially averaged and the observable speckle-noise pattern reduced. This method can be practiced with any of the PLIM-based systems of the present invention disclosed herein, as well as any system constructed in accordance with the general principles of the present invention.

384. The method and apparatus of claim 382, wherein temporal intensity modulation techniques which can be used to carry out the method include, for example: high-speed temporal modulators such as

electro-optical shutters, pupils, and stops, located along the optical path of the composite return PLIB focused by the IFD subsystem; etc.

385. A method and apparatus, wherein a return planar laser illumination beam is temporal intensity modulated prior to image detection by employing high-speed light gating/switching principles.

386. An eighth generalized speckle-noise pattern reduction method of the present invention, wherein a series of consecutively captured digital images of an object, containing speckle-pattern noise, are buffered over a series of consecutively different photo-integration time periods in the hand-held PLIIM-based imager, and thereafter spatially corresponding pixel data subsets defined over a small window in the captured digital images are additively combined and averaged so as to produce spatially corresponding pixels data subsets in a reconstructed image of the object, containing speckle-pattern noise having a substantially reduced level of power.

387. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem comprising a linear (1D) image sensor with vertically-elongated image detection elements, a pair of planar laser illumination modules (PLIMs), and a 2-D PLIB micro-oscillation mechanism arranged therewith for enabling both lateral and transverse micro-movement of the planar laser illumination beam (PLIB).

388. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem comprising a linear (1D) image sensor with vertically-elongated image detection elements, a pair of planar laser illumination modules (PLIMs), and a 2-D PLIB micro-oscillation mechanism arranged therewith for enabling both lateral and transverse micro-movement of the planar laser illumination beam (PLIB).

389. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a micro-oscillating cylindrical lens array and a micro-oscillating PLIB reflecting mirror configured together as an optical assembly for the purpose of micro-oscillating the PLIB laterally along its planar extent as well as transversely along the direction orthogonal thereto, so that during illumination operations, the PLIB is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the

image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

390. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a stationary PLIB folding mirror, a micro-oscillating PLIB reflecting element, and a stationary cylindrical lens array configured together as an optical assembly as shown for the purpose of micro-oscillating the PLIB laterally along its planar extent as well as transversely along the direction orthogonal thereto, so that during illumination operations, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

391. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a micro-oscillating cylindrical lens array and a micro-oscillating PLIB reflecting element configured together as shown as an optical assembly for the purpose of micro-oscillating the PLIB laterally along its planar extent as well as transversely along the direction orthogonal thereto, so that during illumination operations, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal (i.e. transverse) thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

392. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D)

image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a micro-oscillating high-resolution deformable mirror structure, a stationary PLIB reflecting element and a stationary cylindrical lens array configured together as an optical assembly as shown for the purpose of micro-oscillating the PLIB laterally along its planar extent as well as transversely along the direction orthogonal thereto, so that during illumination operation, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal (i.e. transverse) thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

393. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a micro-oscillating cylindrical lens array structure for micro-oscillating the PLIB laterally along its planar extend, a micro-oscillating PLIB/FOV refraction element for micro-oscillating the PLIB and the field of view (FOV) of the linear image sensor transversely along the direction orthogonal to the planar extent of the PLIB, and a stationary PLIB/FOV folding mirror configured together as an optical assembly as shown for the purpose of micro-oscillating the PLIB laterally along its planar extent while micro-oscillating both the PLIB and FOV of the linear image sensor transversely along the direction orthogonal thereto, so that during illumination operation, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal (i.e. transverse) thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

394. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D)

image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a micro-oscillating cylindrical lens array structure for micro-oscillating the PLIB laterally along its planar extend, a micro-oscillating PLIB/FOV reflection element for micro-oscillating the PLIB and the field of view (FOV) of the linear image sensor transversely along the direction orthogonal to the planar extent of the PLIB, and a stationary PLIB/FOV folding mirror configured together as an optical assembly as shown for the purpose of micro-oscillating the PLIB laterally along its planar extent while micro-oscillating both the PLIB and FOV of the linear image sensor transversely along the direction orthogonal thereto, so that during illumination operation, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

395. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a phase-only LCD phase modulation panel, a stationary cylindrical lens array, and a micro-oscillating PLIB reflection element, configured together as an optical assembly as shown for the purpose of micro-oscillating the PLIB laterally along its planar extent while micro-oscillating the PLIB transversely along the direction orthogonal thereto, so that during illumination operation, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal (i.e. transverse) thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

396. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D)

image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a micro-oscillating multi-faceted cylindrical lens array structure, a stationary cylindrical lens array, and a micro-oscillating PLIB reflection element configured together as an optical assembly as shown, for the purpose of micro-oscillating the PLIB laterally along its planar extent while micro-oscillating the PLIB transversely along the direction orthogonal thereto, so that during illumination operation, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

397. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a 2-D PLIB micro-oscillation mechanism arranged with each PLIM, and employing a micro-oscillating multi-faceted cylindrical lens array structure (adapted for micro-oscillation about the optical axis of the VLD's laser illumination beam and along the planar extent of the PLIB) and a stationary cylindrical lens array, configured together as an optical assembly as shown, for the purpose of micro-oscillating the PLIB laterally along its planar extent while micro-oscillating the PLIB transversely along the direction orthogonal thereto, so that during illumination operation, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof as well as along the direction orthogonal thereto, causing the phase along the wavefront of each transmitted PLIB to be modulated in two orthogonal dimensions and numerous substantially different time-varying speckle-noise patterns to be produced at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

398. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench

on opposite sides of the IFD module, and (iii) a hybrid-type PLIB modulation mechanism arranged with each PLIM, and employing a temporal-intensity modulation panel, a stationary cylindrical lens array, and a micro-oscillating PLIB reflection element configured together as an optical assembly as shown, for the purpose of temporal intensity modulating the PLIB uniformly along its planar extent while micro-oscillating the PLIB transversely along the direction orthogonal thereto, so that during illumination operations, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof during micro-oscillation along the direction orthogonal thereto, thereby producing numerous substantially different time-varying speckle-noise patterns at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

399. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a hybrid-type PLIB modulation mechanism arranged with each PLIM, and employing a temporal-intensity modulation panel, a stationary cylindrical lens array, and a micro-oscillating PLIB reflection element configured together as an optical assembly as shown, for the purpose of temporal intensity modulating the PLIB uniformly along its planar extent while micro-oscillating the PLIB transversely along the direction orthogonal thereto, so that during illumination operations, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof during micro-oscillation along the direction orthogonal thereto, thereby producing numerous substantially different time-varying speckle-noise patterns at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

400. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a hybrid-type PLIB modulation mechanism arranged with each PLIM, and employing a visible mode-locked laser diode (MLLD), a stationary cylindrical lens array, and a micro-oscillating PLIB reflection element configured together as an optical assembly as shown, for the purpose of producing a temporal intensity modulated PLIB while micro-oscillating the PLIB transversely along the direction orthogonal to its planar extent, so that during illumination operations, the

PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof during micro-oscillation along the direction orthogonal thereto, thereby producing numerous substantially different time-varying speckle-noise patterns at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

401. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a hybrid-type PLIB modulation mechanism arranged with each PLIM, and employing a visible laser diode (VLD) driven into a high-speed frequency hopping mode, a stationary cylindrical lens array, and a micro-oscillating PLIB reflection element configured together as an optical assembly as shown, for the purpose of producing a temporal frequency modulated PLIB while micro-oscillating the PLIB transversely along the direction orthogonal to its planar extent, so that during illumination operations, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof during micro-oscillation along the direction orthogonal thereto, thereby producing numerous substantially different time-varying speckle-noise patterns at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

402. A PLIIM-based system embodying a speckle-pattern noise reduction subsystem, comprising (i) an image formation and detection (IFD) module mounted on an optical bench and having a linear (1D) image sensor with vertically-elongated image detection elements characterized by a large height-to-width (H/W) aspect ratio, (ii) a pair of planar laser illumination modules (PLIMs) mounted on the optical bench on opposite sides of the IFD module, and (iii) a hybrid-type PLIB modulation mechanism arranged with each PLIM, and employing a micro-oscillating spatial intensity modulation array, a stationary cylindrical lens array, and a micro-oscillating PLIB reflection element configured together as an optical assembly as shown, for the purpose of producing a spatial intensity modulated PLIB while micro-oscillating the PLIB transversely along the direction orthogonal to its planar extent, so that during illumination operations, the PLIB transmitted from each PLIM is spatial phase modulated along the planar extent thereof during micro-oscillation along the direction orthogonal thereto, thereby producing numerous substantially different time-varying speckle-noise patterns at the vertically-elongated image detection elements of the IFD Subsystem during the photo-integration time period thereof, so that these numerous time-varying speckle-noise patterns can be temporally and spatially averaged during the photo-integration time period

of the image detection array, thereby reducing the RMS power level of speckle-noise patterns observed at the image detection array.

403. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, employing linear electronic image detection arrays having elongated image detection elements with a high height-to-width (H/W) aspect ratio.

404. A method of and apparatus for reducing the power of speckle-noise patterns observable at the electronic image detection array of a PLIIM-based system, employing linear (or area) electronic image detection arrays having vertically-elongated image detection elements, i.e. having a high height-to-width (H/W) aspect ratio.

405. A PLIIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein a micro-oscillating cylindrical lens array micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent to produce spatial-incoherent PLIB components and optically combines and projects said spatially-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflecting structure micro-oscillates the PLB components transversely along the direction orthogonal to said planar extent, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the spatially-incoherent components reflected/scattered off the illuminated object.

406. A PLIIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein a first micro-oscillating light reflective element micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent to produce spatially-incoherent PLIB components, a second micro-oscillating light reflecting element micro-oscillates the spatially-incoherent PLIB components transversely along the direction orthogonal to said planar extent, and wherein a stationary cylindrical lens array optically combines and projects said spatially-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the spatially incoherent components reflected/scattered off the illuminated object.

407. A PLIIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein an acousto-optic Bragg cell micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent to produce spatially-incoherent PLIB components, a stationary cylindrical lens array optically combines and projects said spatially-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflecting structure micro-oscillates the spatially-incoherent PLIB components transversely along the direction orthogonal to said planar extent, and a linear (1D) image detection array with vertically-elongated image detection elements

detects time-varying speckle-noise patterns produced by spatially incoherent PLIB components reflected/scattered off the illuminated object.

408. A PLIIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein a high-resolution deformable mirror (DM) structure micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent to produce spatially-incoherent PLIB components, a micro-oscillating light reflecting element micro-oscillates the spatially-incoherent PLIB components transversely along the direction orthogonal to said planar extent, and wherein a stationary cylindrical lens array optically combines and projects the spatially-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by said spatially incoherent PLIB components reflected/scattered off the illuminated object.

409. A PLIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein a micro-oscillating cylindrical lens array micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent to produce spatially-incoherent PLIB components which are optically combined and projected onto the same points on the surface of an object to be illuminated, and a micro-oscillating light reflective structure micro-oscillates the spatially-incoherent PLIB components transversely along the direction orthogonal to said planar extent as well as the field of view (FOV) of a linear (1D) image detection array having vertically-elongated image detection elements, whereby said linear CCD detection array detects time-varying speckle-noise patterns produced by the spatially incoherent PLIB components reflected/scattered off the illuminated object.

410. A PLIIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein a micro-oscillating cylindrical lens array micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent and produces spatially-incoherent PLIB components which are optically combined and project onto the same points of an object to be illuminated, a micro-oscillating light reflective structure micro-oscillates transversely along the direction orthogonal to said planar extent, both PLIB and the field of view (FOV) of a linear (1D) image detection array having vertically-elongated image detection elements, and a PLIB/FOV folding mirror projects the micro-oscillated PLIB and FOV towards said object, whereby said linear image detection array detects time-varying speckle-noise patterns produced by the spatially incoherent PLIB components reflected/scattered off the illuminated object.

411. A PLIIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein a phase-only LCD-based phase modulation panel micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent and produces spatially-incoherent PLIB components, a stationary cylindrical lens array optically combines and projects the spatially-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflecting structure micro-oscillates the spatially-incoherent PLIB components transversely along the direction

orthogonal to said planar extent, and a linear (1D) CCD image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the spatially incoherent PLIB components reflected/scattered off the illuminated object.

412. A PLIIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein a multi-faceted cylindrical lens array structure rotating about its longitudinal axis within each PLIM micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent and produces spatially-incoherent PLIB components therealong, a stationary cylindrical lens array optically combines and projects the spatially-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflecting structure micro-oscillates the spatially-incoherent PLIB components transversely along the direction orthogonal to said planar extent, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the spatially incoherent PLIB components reflected/scattered off the illuminated object.

413. A PLIIM-based system with an integrated speckle-pattern noise reduction subsystem, wherein a multi-faceted cylindrical lens array structure within each PLIM rotates about its longitudinal and transverse axes, micro-oscillates a planar laser illumination beam (PLIB) laterally along its planar extent as well as transversely along the direction orthogonal to said planar extent, and produces spatially-incoherent PLIB components along said orthogonal directions, and wherein a stationary cylindrical lens array optically combines and projects the spatially-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the spatially incoherent PLIB components reflected/scattered off the illuminated object.

414. A PLIIM-based system with an integrated hybrid-type speckle-pattern noise reduction subsystem, wherein a high-speed temporal intensity modulation panel temporal intensity modulates a planar laser illumination beam (PLIB) to produce temporally-incoherent PLIB components along its planar extent, a stationary cylindrical lens array optically combines and projects the temporally-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflecting element micro-oscillates the PLIB transversely along the direction orthogonal to said planar extent to produce spatially-incoherent PLIB components along said transverse direction, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the temporally and spatially incoherent PLIB components reflected/scattered off the illuminated object.

415. A PLIIM-based system with an integrated hybrid-type speckle-pattern noise reduction subsystem, wherein an optically-reflective cavity (i.e. etalon) externally attached to each VLD in the system temporal phase modulates a planar laser illumination beam (PLIB) to produce temporally-incoherent PLIB

components along its planar extent, a stationary cylindrical lens array optically combines and projects the temporally-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflecting element micro-oscillates the PLIB transversely along the direction orthogonal to said planar extent to produce spatially-incoherent PLIB components along said transverse direction, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the temporally and spatially incoherent PLIB components reflected/scattered off the illuminated object.

416. A PLIIM-based system with an integrated hybrid-type speckle-pattern noise reduction subsystem, wherein each visible mode locked laser diode (MLLD) employed in the PLIM of the system generates a high-speed pulsed (i.e. temporal intensity modulated) planar laser illumination beam (PLIB) having temporally-incoherent PLIB components along its planar extent, a stationary cylindrical lens array optically combines and projects the temporally-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflecting element micro-oscillates PLIB transversely along the direction orthogonal to said planar extent to produce spatially-incoherent PLIB components along said transverse direction, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the temporally and spatially incoherent PLIB components reflected/scattered off the illuminated object.

417. A PLIIM-based system with an integrated hybrid-type speckle-pattern noise reduction subsystem, wherein the visible laser diode (VLD) employed in each PLIM of the system is continually operated in a frequency-hopping mode so as to temporal frequency modulate the planar laser illumination beam (PLIB) and produce temporally-incoherent PLIB components along its planar extent, a stationary cylindrical lens array optically combines and projects the temporally-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflecting element micro-oscillates the PLIB transversely along the direction orthogonal to said planar extent and produces spatially-incoherent PLIB components along said transverse direction, and a linear (1D) image detection array with vertically-elongated image detection elements detects time-varying speckle-noise patterns produced by the temporally and spatial incoherent PLIB components reflected/scattered off the illuminated object.

418. A PLIIM-based system with an integrated hybrid-type speckle-pattern noise reduction subsystem, wherein a pair of micro-oscillating spatial intensity modulation panels modulate the spatial intensity along the wavefront of a planar laser illumination beam (PLIB) and produce spatially-incoherent PLIB components along its planar extent, a stationary cylindrical lens array optically combines and projects the spatially-incoherent PLIB components onto the same points on the surface of an object to be illuminated, and wherein a micro-oscillating light reflective structure micro-oscillates said PLIB transversely along the direction orthogonal to said planar extent and produces spatially-incoherent PLIB components along said transverse direction, and a linear (1D) image detection array having vertically-elongated image detection

elements detects time-varying speckle-noise patterns produced by the spatially incoherent PLIB components reflected/scattered off the illuminated object.

419. A PLIIM-based hand-supportable linear imager which contains within its housing, a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 1-D (i.e. linear) image detection array with vertically-elongated image detection elements and configured within an optical assembly that operates in accordance with the first generalized method of speckle-pattern noise reduction of the present invention, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

420. A manually-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/fixed focal distance image formation optics;
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

421. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/fixed focal distance image formation optics;
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating upon detection of an object in its IR-based object detection field, the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

422. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/fixed focal distance image formation optics;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays into a full-power mode of operation, the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

423. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/fixed focal distance image formation optics;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

424. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/fixed focal distance image formation optics;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the image processing computer for decode-processing upon automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

425. A manually-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;

(ii) a manually-actuated trigger switch for manually activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and

(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

426. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;

(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating upon detection of an object in its IR-based object detection field, the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

427. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;

(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays into a full-power mode of operation, the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image

processing computer, via the camera control computer, upon automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

428. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module; and
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame.

429. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and fixed focal length/variable focal distance image formation optics;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the image processing computer for decode-processing upon automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame, and (iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

430. A manually-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image

frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and

(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

431. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics,

(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating upon detection of an object in its IR-based object detection field, the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

432. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;

(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays into a full-power mode of operation, the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object in its laser-based object detection field;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

433. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;

(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination arrays (driven by a set of VLD driver circuits), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

434. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a linear image detection array with vertically-elongated image detection elements and variable focal length/variable focal distance image formation optics;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the image processing computer for decode-processing upon automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

435. A PLIIM-based image capture and processing engines with linear image detection array having vertically-elongated image detection elements and an integrated despeckling mechanism.

436. A PLIIM-based image capture and processing engine for use in a hand-supportable imager.

437. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA, and a 2-D (area-type) image detection array configured within an optical assembly that employs a micro-oscillating cylindrical lens array which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

438. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and an area image detection array configured within an optical assembly which employs a micro-oscillating light reflective element that provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

439. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs an acousto-electric Bragg cell structure which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

440. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a high spatial-resolution piezo-electric driven deformable mirror (DM) structure which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

441. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a spatial-only liquid crystal display (PO-LCD) type spatial phase modulation panel which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

442. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a visible mode locked laser diode (MLLD) which provides a despeckling mechanism that operates in accordance with the second generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

443. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs an electrically-passive optically-reflective cavity (i.e. etalon) which provides a despeckling mechanism that operates in accordance with the third method generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

444. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a pair of micro-oscillating spatial intensity modulation panels which provide a despeckling mechanism that operates in accordance with the fifth method generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

445. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a electro-optical or mechanically rotating aperture (i.e. iris) disposed before the entrance pupil of the IFD module, which provides a despeckling mechanism that operates in accordance with the sixth method generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

446. A hand-supportable imager having a housing containing a PLIIM-based image capture and processing engine comprising a dual-VLD PLIA and a 2-D image detection array configured within an optical assembly that employs a high-speed electro-optical shutter disposed before the entrance pupil of the IFD module, which provides a despeckling mechanism that operates in accordance with the seventh generalized method of speckle-pattern noise reduction, and which also has integrated with its housing, a LCD display panel for displaying images captured by said engine and information provided by a host computer system or other information supplying device, and a manual data entry keypad for manually entering data into the imager during diverse types of information-related transactions supported by the PLIIM-based hand-supportable imager.

447. A manually-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type (i.e. 1D) image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to producing a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon response to the manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

448. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating upon detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

449. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);

(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

450. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);

(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

451. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of view (FOV);

(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the image processing computer for decode-processing in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

452. A manually-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear -type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of view (FOV);
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination (to produce a planar laser illumination beam (PLIB) in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

453. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of view (FOV);
(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating in response to the detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

454. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of view (FOV);
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the a linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to the decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

455. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of FOV,;

(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module; and

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame.

456. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear -type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a field of view (FOV);

(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the image processing computer for decode-processing in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

457. A manually-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a field of FOV;

(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and

(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

458. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a field of view (FOV);

(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating in response to the detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;
(ii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

459. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics and a field of view;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

460. An automatically-activated PLIIM-based hand-supportable linear imager comprising:
(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a field of view (FOV);
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV) the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

461. An automatically-activated PLIIM-based hand-supportable linear imager comprising:

(i) a linear-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a field of view (FOV);

(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV) the linear-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, the image processing computer for decode-processing in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

462. A manually-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type (i.e. 2D) image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a field of field of view (FOV);

(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and

(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

463. An automatically-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a FOV;

(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating in response to the detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

464. An automatically-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a FOV;
(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

465. An automatically-activated PLIIM-based hand-supportable area imager shown comprising:
(i) a area-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a FOV;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

466. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/fixed focal distance image formation optics with a FOV;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the image processing computer for decode-processing upon automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

467. A manually-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;

(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optic; and

(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

468. An automatically-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;

(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating, in response to the detection of an object in its IR-based object detection field, the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

469. An automatically-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;

(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via, the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

470. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;
(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, upon automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;, and
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system upon decoding a bar code symbol within a captured image frame.

471. An automatically-activated PLIIM-based hand-supportable area imager comprising:
i) an area-type image formation and detection (IFD) module having a fixed focal length/variable focal distance image formation optics with a FOV;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer for decode-processing of image data in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

472. A manually-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;
(ii) a manually-actuated trigger switch for manually activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to manual activation of the trigger switch, and capturing images of objects (i.e. bearing bar code symbols and other graphical indicia) through the fixed focal length/fixed focal distance image formation optics; and
(iii) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

473. An automatically-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;

(ii) an IR-based object detection subsystem within its hand-supportable housing for automatically activating in response to the detection of an object in its IR-based object detection field, the planar laser illumination arrays (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, as well as the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer,;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

474. An automatically-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;

(ii) a laser-based object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array into a full-power mode of operation (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object in its laser-based object detection field;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

475. An automatically-activated PLIIM-based hand-supportable area imager comprising:

(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;

(ii) an ambient-light driven object detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer, via the camera control computer, in response to the automatic detection of an object via ambient-light detected by object detection field enabled by the image sensor within the IFD module;

(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to the decoding a bar code symbol within a captured image frame; and

(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

476. An automatically-activated PLIIM-based hand-supportable area imager comprising:
(i) an area-type image formation and detection (IFD) module having a variable focal length/variable focal distance image formation optics with a FOV;
(ii) an automatic bar code symbol detection subsystem within its hand-supportable housing for automatically activating the planar laser illumination array (to produce a PLIB in coplanar arrangement with said FOV), the area-type image formation and detection (IFD) module, the image frame grabber, the image data buffer, and the image processing computer for decode-processing of image data in response to the automatic detection of an bar code symbol within its bar code symbol detection field enabled by the image sensor within the IFD module;
(iii) a manually-activatable switch for enabling transmission of symbol character data to a host computer system in response to decoding a bar code symbol within a captured image frame; and
(iv) a LCD display panel and a data entry keypad for supporting diverse types of transactions using the PLIIM-based hand-supportable imager.

477. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising PLIAs, and IFD (i.e. camera) subsystem and associated optical components mounted on an optical-bench/multi-layer PC board, contained between the upper and lower portions of the engine housing.

478. A PLIIM-based image capture and processing engine for use in a PLIIM-based hand-supportable linear imager comprising a housing containing a dual-VLD PLIA and a linear image detection array with vertically-elongated image detection elements configured within an optical assembly that provides a despeckling mechanism which operates in accordance with the first generalized method of speckle-pattern noise reduction.

479. A PLIIM-based image capture and processing engine for use in a PLIIM-based hand-supportable linear imager comprising a housing containing a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction.

480. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly which employs high-resolution deformable mirror (DM) structure which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction.

481. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array

having vertically-elongated image detection elements configured within an optical assembly that employs a high-resolution phase-only LCD-based phase modulation panel which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction.

482. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly that employs a rotating multi-faceted cylindrical lens array structure which provides a despeckling mechanism that operates in accordance with the first generalized method of speckle-pattern noise reduction.

483. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly that employs a high-speed temporal intensity modulation panel (i.e. optical shutter) which provides a despeckling mechanism that operates in accordance with the second generalized method of speckle-pattern noise reduction.

484. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly that employs visible mode-locked laser diode (MLLDs) which provide a despeckling mechanism that operates in accordance with the second method generalized method of speckle-pattern noise reduction.

485. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly that employs an optically-reflective temporal phase modulating structure (i.e. etalon) which provides a despeckling mechanism that operates in accordance with the third generalized method of speckle-pattern noise reduction.

486. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly that employs a pair of reciprocating spatial intensity modulation panels which provide a despeckling mechanism that operates in accordance with the fifth method generalized method of speckle-pattern noise reduction.

487. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array

having vertically-elongated image detection elements configured within an optical assembly that employs spatial intensity modulation aperture which provides a despeckling mechanism that operates in accordance with the sixth method generalized method of speckle-pattern noise reduction.

488. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly that employs a temporal intensity modulation aperture which provides a despeckling mechanism that operates in accordance with the seventh generalized method of speckle-pattern noise reduction.

489. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly that employs an image processing subsystem which provides a despeckling mechanism that operates in accordance with the seventh generalized method of speckle-pattern noise reduction.

490. A PLIIM-based image capture and processing engine for use in the hand-supportable imagers, presentation scanners, and the like, comprising a dual-VLD PLIA and a linear image detection array having vertically-elongated image detection elements configured within an optical assembly that employs an image formation and detection (IFD) subsystem which provides a despeckling mechanism that operates in accordance with the eighth generalized method of speckle-pattern noise reduction.

491. A PLIIM-based hand-supportable imager having a 2D PLIIM-based engine and an integrated despeckling mechanism

492. A method of and apparatus for mounting a linear image sensor chip within a PLIIM-based system to prevent misalignment between the field of view (FOV) of said linear image sensor chip and a planar laser illumination beam (PLIB) produced by said PLIIM-based system, in response to thermal expansion or cycling within said PLIIM-based system.

493. Apparatus for mounting a linear image sensor chip within a PLIIM-based system to prevent misalignment between the field of view (FOV) of said linear image sensor chip and a planar laser illumination beam (PLIB) produced by said PLIIM-based system, in response to thermal expansion or cycling within said PLIIM-based system.

494. A method of mounting a linear image sensor chip relative to a heat sinking structure to prevent any misalignment between the field of view (FOV) of said linear image sensor chip and a PLIB produced by a PLIA within a PLIIM-based camera system, thereby improving the performance of the PLIIM-based camera system during planar laser illumination and imaging operations.

495. Apparatus for mounting a linear image sensor chip relative to a heat sinking structure to prevent any misalignment between the field of view (FOV) of the linear image sensor chip and the PLIA produced by the PLIA within the camera subsystem, thereby improving the performance of the PLIIM-based system during planar laser illumination and imaging operations.

496. A camera subsystem wherein a linear image sensor chip employed in said camera subsystem is rigidly mounted to the camera body of a PLIIM-based system via an image sensor mounting mechanism which prevents any significant misalignment between the field of view (FOV) of the image detection elements on said linear image sensor chip and a planar laser illumination beam (PLIB) produced by a PLIA in said PLIIM-based system, used to illuminate the FOV thereof within the camera subsystem.

497. An object identification and attribute acquisition system of unitary construction, comprising:
a system housing of unitary construction having a first light transmission aperture, a second light transmission aperture, and a third light transmission aperture, wherein said first and second light transmission apertures are spatially aligned with each other, and said third light transmission aperture is disposed at a predetermined distance away from said first and second light transmission apertures;
a linear PLIIM-based imaging subsystem mounted within said system housing and having

a planar laser illumination array (PLIA) for producing and projecting a planar laser illumination beam (PLIB) through said first light transmission aperture, so as to illuminate an object as it is transported past said linear PLIIM-based imaging subsystem, and

an image formation and detection (IFD) module having a linear image detection array and imaging forming optics with automatic zoom and focus control for providing said linear image detection array with a variable field of view (FOV) which is projected through said second light transmission aperture, and along which images of illuminated portions of said object can be detected,

wherein said PLIB and FOV are arranged in a coplanar relationship along the working range of said so that the PLIB illuminates primarily within said variable FOV of the IFD module;
a LDIP subsystem mounted within said system housing, for producing an amplitude modulated (AM) laser scanning beam which are projected through said third light transmission aperture so as to scan the surface of said transported object and measure the surface profile characteristics thereof in relation to a predetermined coordinate reference system, and generate control data for use within said object identification and attribute acquisition system;
a camera control computer, mounted within said system housing, for controlling the operation of said PLIIM-based imaging subsystem, in response to control data generated by said LDIP subsystem and transmitted to said camera control computer;
wherein, in response to said control data signals, said camera control computer generates digital camera control signals which are provided to said IFD module so that said linear PLIIM-based imaging subsystem can capture and buffer digital images of said transported object; and

wherein each said digital image has (i) substantially square pixels (i.e. 1:1 aspect ratio) independent of object height or velocity, and (ii) constant image resolution measured in dots per inch (dpi) independent of object height or velocity and without the use of telecentric optics.

498. The object identification and attribute acquisition system of claim 497, wherein said LDIP subsystem produces a pair of laser scanning beams which are projected through said third light transmission aperture so as to scan the surface of said transported object, measure the surface profile characteristics thereof in relation to a predetermined coordinate reference system, and determine the velocity of said transported object.

499. The object identification and attribute acquisition system of claim 497, wherein said camera control computer further generates digital camera control signals which are provided to said IFD module so that said linear PLIIM-based imaging subsystem automatically crops captured digital images so that only regions of interest reflecting the object or object label require image processing by an image processing computer.

500. The object identification and attribute acquisition system of claim 497, wherein said camera control computer automatically controls the photo-integration time period of the IFD subsystem using object velocity computations in its LDIP subsystem, so as to ensure that each pixel in each image captured by the system has a substantially square aspect ratio.

501. A PLIIM-based object identification and attribute acquisition system, in which FTP service is provided to enable the uploading of system and application software from an FTP site on the Internet, and/or downloading of diagnostic error tables maintained in a central management information database.

502. A PLIIM-based object identification and attribute acquisition system, in which SMTP service is provided for issuing outgoing-mail messages to a remote service technician.

503. An object identification and attribute acquisition of unitary construction, wherein packages, arranged in a singulated or non-singulated configuration, are transported along a high-speed conveyor belt, detected and dimensioned by a LADAR-based imaging and profiling (LDIP) subsystem, and identified by an automatic PLIIM-based bar code symbol reading system employing a 1-D (i.e. linear) type CCD scanning array, below which a variable focus imaging lens is mounted for imaging bar coded packages transported therebeneath in a fully automated manner.

504. An object identification and attribute acquisition system of unitary construction, comprising:
a housing of compact construction supportable above a conveyor belt structure;
a LADAR-based object detection and dimensioning subsystem for detecting and dimensioning objects transport;

a PLIIM-based linear image acquisition subsystem for use in reading bar code symbols on transported objects;
a data-element queuing, handling and processing subsystem;
an input/output (unit) subsystem;
an I/O port for a graphical user interface (GUI);
a network interface controller (for supporting networking protocols such as Ethernet, IP, etc.); and
wherein said components are integrated together as a fully working unit contained within

505. An object identification and attribute acquisition system comprising:
a unitary housing having a first optically-isolated compartment formed in the upper deck portion of said unitary housing for containing a linear PLIIM-based imaging subsystem and associated components therewithin; and
a second optically-isolated compartment formed in the lower deck portion of said unitary housing, disposed below said first optically-isolated compartment, for containing a laser-based object profiling subsystem and associated components therewithin;
a first light transmission aperture formed in said first optically-isolated compartment, for enabling the transmission of a planar laser illumination beam (PLIB) from a planar laser illumination array (PLIA) mounted within said first optically-isolated compartment towards an object to be illuminated by said PLIB;
a second light transmission aperture formed in said first optically-isolated compartment, and spatially aligned with said first light transmission aperture, for enabling the transmission of a field of view (FOV) of a linear image detection array provided in said PLIIM-based imaging subsystem, to project from said linear image detection array towards said illuminated object to be imaged within said FOV which is coplanar with said PLIB; and
a third light transmission aperture formed in said second optically-isolated compartment, and spatially distanced from said first optically-isolated compartment, for enabling the transmission of one or more laser scanning beams from said laser-based object profiling subsystem towards said object being illuminated and imaged, so as to profile the surface of said object.

506. The object identification and attribute acquisition system of claim 505, wherein said laser-based object profiling subsystem is a laser doppler imaging and profiling (LDIP) based subsystem capable of producing a pair of angularly spaced apart AM laser scanning beams for transmission through said third light transmission aperture, and measuring the profile characteristics of objects laser scanned thereby as well as the velocity of said objects.

507. A PLIIM-based imaging system comprising:
an image formation and detection (IFD) subsystem including
a stationary linear image detection array;
a stationary lens system mounted before said stationary linear (CCD-type) image detection array;

a first movable lens system for stepped movement relative to said stationary lens system during image zooming operations; and

a second movable lens system for stepped movements relative to said first movable lens system and said stationary lens system during image focusing operations.

508. A object attribute acquisition and analysis system completely contained within a single housing of compact lightweight construction .

509. An object identification and attribute acquisition system, which is capable of (1) acquiring and analyzing in real-time the physical attributes of objects such as, for example, (i) the surface reflectively characteristics of objects, (ii) geometrical characteristics of objects, including shape measurement, (iii) the motion (i.e. trajectory) and velocity of objects, as well as (iv) bar code symbol, textual, and other information-bearing structures disposed thereon, and (2) generating information structures representative thereof for use in diverse applications including, for example, object identification, tracking, and/or transportation/routing operations.

510. An object identification and attribute acquisition system, wherein a multi-wavelength i.e. color-sensitive) Laser Doppler Imaging and Profiling (LDIP) subsystem is provided for acquiring and analyzing (in real-time) the physical attributes of objects such as, for example, (i) the surface reflectively characteristics of objects, (ii) geometrical characteristics of objects, including shape measurement, and (iii) the motion (i.e. trajectory) and velocity of objects.

511. An object identification and attribute acquisition system, wherein an image formation and detection (i.e. camera) subsystem is provided having (i) a planar laser illumination and monochromatic imaging (PLIIM) subsystem, (ii) intelligent auto-focus/auto-zoom imaging optics, and (iii) a high-speed electronic image detection array with height/velocity-driven photo-integration time control to ensure the capture of images having constant image resolution (i.e. constant dpi) independent of package height.

512. An object identification and attribute acquisition system, wherein an advanced image-based bar code symbol decoder is provided for reading 1-D and 2-D bar code symbol labels on objects, and an advanced optical character recognition (OCR) processor is provided for reading textual information, such as alphanumeric character strings, representative within digital images that have been captured and lifted from the system.

513. An object identification and attribute acquisition system for use in the high-speed parcel, postal and material handling industries.

514. An object identification and attribute acquisition system, which is capable of being used to identify, track and route packages, as well as identify individuals for security and personnel control applications.

515. An object identification and attribute acquisition system which enables bar code symbol reading of linear and two-dimensional bar codes, OCR-compatible image lifting, dimensioning, singulation, object (e.g. package) position and velocity measurement, and label-to-parcel tracking from a single overhead-mounted housing measuring one 20" x 20" x 8".

516. An object identification and attribute acquisition system which employs a built-in source for producing a planar laser illumination beam that is coplanar with the field of view of the imaging optics used to form images on an electronic image detection array, thereby eliminating the need for large, complex, high-power consuming sodium vapor lighting equipment used in conjunction with most industrial CCD cameras.

517. An object identification and attribute acquisition system, which utilizes a single input cable for supplying input (AC) power and a single output cable for outputting digital data to host systems.

518. An object identification and attribute acquisition system, wherein such systems can be configured to construct multi-sided tunnel-type imaging systems, used in airline baggage handling systems, as well as in postal and parcel identification, dimensioning and sortation systems.

519. An object identification and attribute acquisition system, for use in (i) automatic checkout solutions installed within retail shopping environments (e.g. supermarkets), (ii) security and people analysis applications, (iii) object and/or material identification and inspection systems, as well as (iv) diverse portable, in-counter and fixed applications in virtual any industry.

520. An object identification and attribute acquisition system in the form of a high-speed object identification and attribute acquisition system, wherein the PLIIM subsystem projects a field of view through a first light transmission aperture formed in the system housing, and a pair of planar laser illumination beams through second and third light transmission apertures which are optically isolated from the first light transmission aperture to prevent laser beam scattering within the housing of the system, and the LDIP subsystem projects a pair of laser beams at different angles through a fourth light transmission aperture.

521. An automated unitary-type package identification and measuring system (i.e. contained within a single housing or enclosure), wherein a PLIIM-based scanning subsystem is used to read bar codes on packages passing below or near the system, while a package dimensioning subsystem is used to capture information about the package prior to being identified.

522. An automated package identification and measuring system, wherein Laser Detecting And Ranging (LADAR-based) scanning methods are used to capture two-dimensional range data maps of the space

above a conveyor belt structure, and two-dimensional image contour tracing methods are used to extract package dimension data therefrom.

523. A unitary object identification and attribute acquisition system which is capable of (1) acquiring and analyzing in real-time the physical attributes of objects such as, for example, (i) the surface reflectivity characteristics of objects, (ii) geometrical characteristics of objects, including shape measurement, (iii) the motion (i.e. trajectory) and velocity of objects, as well as (iv) bar code symbol, textual, and other information-bearing structures disposed thereon, and (2) generating information structures representative thereof for use in diverse applications including, for example, object identification, tracking, and/or transportation/routing operations.

524. A unitary object identification and attribute acquisition system, wherein a multi-wavelength (i.e. color-sensitive) Laser Doppler Imaging and Profiling (LDIP) subsystem is provided for acquiring and analyzing (in real-time) the physical attributes of objects such as, for example, (i) the surface reflectivity characteristics of objects, (ii) geometrical characteristics of objects, including shape measurement, and (iii) the motion (i.e. trajectory) and velocity of objects.

525. A unitary object identification and attribute acquisition system, wherein an image formation and detection (i.e. camera) subsystem is provided having (i) a planar laser illumination and imaging (PLIIM) subsystem, (ii) intelligent auto-focus/auto-zoom imaging optics, and (iii) a high-speed electronic image detection array with height/velocity-driven photo-integration time control to ensure the capture of images having constant image resolution (i.e. constant dpi) independent of package height.

526. A unitary object identification and attribute acquisition system, wherein an advanced image-based bar code symbol decoder is provided for reading 1-D and 2-D bar code symbol labels on objects, and an advanced optical character recognition (OCR) processor is provided for reading textual information, such as alphanumeric character strings, representative within digital images that have been captured and lifted from the system.

527. A unitary object identification and attribute acquisition system which enables bar code symbol reading of linear and two-dimensional bar codes, OCR-compatible image lifting, dimensioning, singulation, object (e.g. package) position and velocity measurement, and label-to-parcel tracking from a single overhead-mounted housing measuring less than or equal to 20 inches in width, 20 inches in length, and 8 inches in height.

528. A unitary object identification and attribute acquisition system which employs a built-in source for producing a planar laser illumination beam that is coplanar with the field of view (FOV) of the imaging optics used to form images on an electronic image detection array, thereby eliminating the need for large,

complex, high-power power consuming sodium vapor lighting equipment used in conjunction with most industrial CCD cameras.

529. A unitary object identification and attribute acquisition system which can be configured to construct multi-sided tunnel-type imaging systems, used in airline baggage-handling systems, as well as in postal and parcel identification, dimensioning and sortation systems.

530. A unitary object identification and attribute acquisition system, for use in (i) automatic checkout solutions installed within retail shopping environments (e.g. supermarkets), (ii) security and people analysis applications, (iii) object and/or material identification and inspection systems, as well as (iv) diverse portable, in-counter and fixed applications in virtual any industry.

531. A unitary object identification and attribute acquisition system in the form of a high-speed object identification and attribute acquisition system, wherein the PLIIM subsystem projects a field of view through a first light transmission aperture formed in the system housing, and a pair of planar laser illumination beams through second and third light transmission apertures which are optically isolated from the first light transmission aperture to prevent laser beam scattering within the housing of the system, and the LDIP subsystem projects a pair of laser beams at different angles through a fourth light transmission aperture.

532. A unitary-type package identification and measuring system contained within a single housing or enclosure, wherein a PLIIM-based scanning subsystem is used to read bar codes on packages passing below or near the system, while a package dimensioning subsystem is used to capture information about attributes (i.e. features) about the package prior to being identified.

533. A planar laser illumination and imaging (PLIIM) system comprising:
a linear (i.e. 1-dimensional) type image formation and detection (IFD) module having a fixed focal length imaging lens, a fixed focal distance and fixed field of view;
a pair of planar laser illumination arrays (PLIAs) mounted on opposite sides of said linear (i.e. 1-dimensional) type image formation and detection (IFD) module, such that said pair of planar illumination arrays (PLIAs) produce a substantially planar laser beam illumination which is disposed substantially coplanar with the field of view of the image formation and detection module during object illumination and image detection operations carried out by the PLIIM system on a moving bar code symbol or other graphical structure.

534. The PLIIM system of claim 533, wherein the field of view of the image formation and detection (IFD) module is folded in the downwardly imaging direction by a field of view folding mirror so that both the folded field of view and said planar laser illumination beam are arranged in a substantially coplanar relationship during object illumination and image detection operations.

535. The PLIIM system of claim 533, wherein the linear image formation and detection module is shown comprising a linear array of photo-electronic detectors realized using CCD technology, wherein each said each planar laser illumination array comprising an array of planar laser illumination modules, wherein each said planar laser illumination module (PLIM) a visible laser diode (VLD), a light collimating lens, and a cylindrical-type lens element configured together to produce a focused beam of planar laser illumination.

536. The PLIIM system of claim 535, wherein said focused beam of planar laser illumination from said collimating lens is directed on the input side of said cylindrical lens, and the output beam produced therefrom is a planar laser illumination beam expanded (i.e. spread out) along the plane of propagation.

537. The PLIIM system of claim 535, wherein said laser beam is transmitted through said cylindrical lens without expansion in the direction normal to the plane of propagation, but is focused by said collimating lens at a point residing within a plane located at the farthest object distance supported by said PLIIM system.

538. The PLIIM system of claim 535, further comprising:
a set of VLD driver circuits for driving the VLDs;
a stationary field of view (FOV) folding mirror for folding the fixed field of view of said linear image formation and detection module in a direction that is coplanar with the plane of laser illumination beams produced by said planar laser illumination arrays;
an image frame grabber;
an image data buffer;
an image processing computer; and
a camera control computer.

539. The PLIIM system of claim 533, wherein the linear image formation and detection module is folded in the downwardly imaging direction by the field of view folding mirror, and the planar laser illumination beam produced by each planar laser illumination module is directed in the imaging direction such that both the folded field of view and planar laser illumination beams are arranged in a substantially coplanar relationship during object illumination and image detection operations.

540. The PLIIM system of claim 533, wherein the field of view of the image formation and detection module is folded in the downwardly imaging direction by the field of view folding mirror, and the planar laser illumination beam produced by each planar laser illumination module is directed along the imaging direction such that both the folded field of view and stationary planar laser illumination beams are arranged in a substantially coplanar relationship during object illumination and image detection operations.

541. The PLIIM System of claim 533 which further comprises a light shield which can be used in the PLIIM system to visually block portions of planar laser illumination beams which extend beyond the scanning field of the system, and could pose a health risk to humans if viewed thereby during system operation.

542. The PLIIM System of claim 533 which further comprises a light shield which can be used in the PLIIM system to visually block portions of planar laser illumination beams which extend beyond the scanning field of the system, and could pose a health risk to humans if viewed thereby during system operation.

543. The PLIIM System of claim 533, wherein said planar laser illumination array (PLIA) comprises an array of visible laser diodes (VLDs), each mounted within a VLD mounting block wherein a focusing lens is mounted and on the end of which there is a v-shaped notch or recess, within which a cylindrical lens element is mounted, and wherein each ~~such~~ VLD mounting block is mounted on an L-bracket for mounting within the housing of the PLIIM system.

544. The PLIIM System of claim 533, wherein said cylindrical lens element is mounted at the end of the VLD mounting block, so that the central axis of the cylindrical lens element is substantially perpendicular to the optical axis of the focusing lens.

545. A method of automatically controlling the output optical power of the laser diodes in a planar laser illumination array (PLIA) in a PLIIM-based imaging system, comprising the steps: in response to the detected speed of objects transported along a conveyor belt or like structure, so that each digital image of each object captured by said PLIIM-based imaging system has a substantially uniform "white" level, regardless of conveyor belt speed, thereby simplifying the software-based image processing operations which need to subsequently carried out by the image processing computer subsystem.

546. Apparatus for automatically controlling the output optical power of the VLDs in the planar laser illumination array (PLIA) of a PLIIM-based imaging system in response to the detected speed of objects transported along a conveyor belt, so that each digital image of each object captured by said PLIIM-based imaging system has a substantially uniform "white" level, regardless of conveyor belt speed, thereby simplifying the software-based image processing operations which need to subsequently carried out by the image processing computer subsystem.

547. A method of automatically controlling the output optical power of laser diodes in the planar laser illumination array (PLIA) of a PLIIM-based imaging system comprising the steps: a camera control computer provided in said PLIIM-based imaging system performs the following operations: (i) computes the optical power which each laser diode in said PLIIM-based imaging system must produce in order that

each digital image captured by said PLIIM-based imaging system will have substantially the same "white" level, regardless of conveyor belt speed; and (2) transmits the computed optical power value(s) of said laser diodes to a micro-controller associated with said PLIA in said PLIIM-based imaging system.

548. Apparatus for automatically controlling the output optical power of laser diodes in the planar laser illumination array (PLIA) of a PLIIM-based imaging system, comprising: a camera control computer provided in said PLIIM-based imaging system programmed to performs the following operations: (i) computes the optical power which each laser diode in said PLIIM-based imaging system must produce in order that each digital image captured by said PLIIM-based imaging system will have substantially the same "white" level, regardless of conveyor belt speed; and (2) transmits the computed optical power value(s) of said laser diodes to a micro-controller associated with said PLIA in said PLIIM-based imaging system.

549. A planar laser illumination and imaging (PLIIM) system for producing digital images of objects having pixels with a substantially constant white-level, said system comprising:

a system housing of unitary construction having a first light transmission aperture, a second light transmission aperture, and a third light transmission aperture, wherein said first and second light transmission apertures are spatially aligned with each other, and said third light transmission aperture is disposed at a predetermined distance away from said first and second light transmission apertures;

a linear PLIIM-based imaging subsystem mounted within said system housing and having

a planar laser illumination array (PLIA) including a plurality of laser diodes for producing and projecting a planar laser illumination beam (PLIB) through said first light transmission aperture, so as to illuminate an object as it is transported past said PLIIM system, and

an image formation and detection (IFD) module having a linear image detection array and imaging forming optics for providing said linear image detection array with a field of view (FOV) which is projected through said second light transmission aperture, and along which images of illuminated portions of said object can be detected,

wherein said PLIB and FOV are arranged in a coplanar relationship along the working range of said PLIIM system so that the PLIB illuminates primarily within said FOV of the IFD module;

a laser scanning object velocity measurement subsystem mounted within said system housing, for producing a pair of amplitude modulated (AM) laser scanning beams which are projected through said third light transmission aperture so as to scan the surface of said transported object and measure the velocity thereof and generate control data for use within said PLIIM system;

a camera control computer, mounted within said system housing, for controlling the operation of said linear PLIIM-based imaging subsystem, in response to control data generated by said laser scanning object velocity measurement subsystem and transmitted to said camera control computer,

wherein said camera control computer (i) computes the optical power which each laser diode in said linear PLIIM-based imaging system must produce in order that each digital image captured by said PLIIM system will have substantially the same "white" level, independent of object velocity; and (2)

transmits control signals to said laser diodes in order to control the operation thereof so that said PLIIM subsystem produces digital images of said object, wherein each the pixels in each said digital image have a substantially constant white-level independent of the measured object velocity.

550. A method of automatically compensating for viewing-angle distortion in a linear PLIIM-based imaging and profiling system which would otherwise occur when digital images of object surfaces are captured as said object surfaces, arranged at a skewed viewing angle, move past a coplanar PLIB/FOV of said linear PLIIM-based imaging and profiling system, and said linear PLIIM-based imaging system including a planar laser illumination array (PLIA) for producing a planar laser illumination beam (PIB) for illuminating said object surface, a LDIP-based object profiling subsystem for profiling said object surface, and an image formation and detection (IFD) subsystem provided with a linear image detection array having a field of view (FOV) that is coplanar with said PLIB, said method comprises the steps of:

(a) computing the line rate for said linear image detection array (dots/second) in said IFD subsystem using (i) the object velocity (inches/second) determined or acquired by said LDIP-based object profiling subsystem, and (ii) the constant image resolution (dots/inch) desired in said PLIIM-based imaging and profiling system;

(b) computing a gradient or slope value for the object surface laser scanned by said AM laser scanning beams projected from said LDIP-based object profiling subsystem;

(c) computing a compensation factor for said computed line rate using said computed gradient or slope value computed in step (b);

computing a compensated line rate for the IFD subsystem using said computed line rate and said computed compensation factor; and

(d) using said compensated line rate to control the line rate of said linear image detection array employed in said IFD subsystem.

551. Apparatus for automatically compensating for viewing-angle distortion in a linear PLIIM-based imaging and profiling system which would otherwise occur when digital images of object surfaces are captured as said object surfaces, arranged at a skewed viewing angle, move past a coplanar PLIB/FOV of said linear PLIIM-based imaging and profiling system, said apparatus comprising:

said linear PLIIM-based imaging system including a planar laser illumination array (PLIA) for producing a planar laser illumination beam (PIB) for illuminating said object surface;

a LDIP-based object profiling subsystem for profiling said object surface;

an image formation and detection (IFD) subsystem provided with a linear image detection array having a field of view (FOV) that is coplanar with said PLIB; and

a camera control compute for performing the following operations in a periodic manner:

(a) computing the line rate for said linear image detection array (dots/second) in said IFD subsystem using (i) the object velocity (inches/second) determined or acquired by said LDIP-based object profiling subsystem, and (ii) the constant image resolution (dots/inch) desired in said PLIIM-based imaging and profiling system;

(b) computing a gradient or slope value for the object surface laser scanned by said AM laser scanning beams projected from said LDIP-based object profiling subsystem;

(c) computing a compensation factor for said computed line rate using said computed gradient or slope value computed in step (b);

computing a compensated line rate for the IFD subsystem using said computed line rate and said computed compensation factor; and

(d) using said compensated line rate to control the line rate of said linear image detection array employed in said IFD subsystem.

552. Apparatus for automatically compensating for viewing-angle distortion in PLIIM-based linear imaging and profiling systems which would otherwise occur when images of object surfaces are being captured as object surfaces, arranged at skewed viewing angles, move past the coplanar PLIB/FOV of such PLIIM-based linear imaging and profiling systems, configured for top and side imaging operations.

553. A method of and apparatus for automatically compensating for viewing-angle distortion in PLIIM-based linear imaging and profiling systems by way of dynamically adjusting the line rate of the camera (i.e. IFD) subsystem, in automatic response to real-time measurement of the object surface gradient (i.e. slope) computed by the camera control computer using object height data captured by the LDIP subsystem.

554. A method of and apparatus for automatically compensating for viewing-angle distortion in PLIIM-based linear imaging and profiling systems by way of dynamically adjusting the line rate of the camera (i.e. IFD) subsystem, in automatic response to real-time measurement of the object surface gradient (i.e. slope) computed by the camera control computer using object height data captured by the LDIP subsystem.

555. A real-time camera control process carried out within a camera control computer in a PLIIM-based camera system, for intelligently enabling the camera system to zoom in and focus upon only the surfaces of a detected package which might bear package identifying and/or characterizing information that can be reliably captured and utilized by the system or network within which the camera subsystem is installed.

556. A real-time camera control process for significantly reducing the amount of image data captured by the system which does not contain relevant information, thus increasing the package identification performance of the camera subsystem, while using less computational resources, thereby allowing the camera subsystem to perform more efficiently and productivity.

557. A camera control computer for generating real-time camera control signals that drive the zoom and focus lens group translators within a high-speed auto-focus/auto-zoom digital camera subsystem so that the camera automatically captures digital images having (1) square pixels (i.e. 1:1 aspect ratio)

independent of package height or velocity, (2) significantly reduced speckle-noise levels, and (3) constant image resolution measured in dots per inch (dpi) independent of package height or velocity.

558. An auto-focus/auto-zoom digital camera system employing a camera control computer which generates commands for cropping the corresponding slice (i.e. section) of the region of interest in the image being captured and buffered therewithin, or processed at an image processing computer.

559. A package dimensioning and identification system contained in a single housing of compact construction, wherein a planar laser illumination and monochromatic imaging subsystem is integrated with a Laser Doppler Imaging and Profiling (LDIP) subsystem and contained within a single housing of compact construction.

560. A package dimensioning and identification system, wherein the system of claim 1 projects a field of view through a first light transmission aperture formed in the system housing, and a pair of planar laser illumination beams through second and third light transmission apertures which are optically isolated from the first light transmission aperture to prevent laser beam scattering within the housing of the system, and the LDIP subsystem projects a pair of laser beams at different angles through a fourth light transmission aperture.

561. A package identification and measuring system, wherein an image-based scanning subsystem is used to read bar codes on packages passing below or near the system, while a package dimensioning subsystem is used to capture information about the package prior to being identified.

562. A unitary PLIIM-based object identification and attribute acquisition system comprising: a Real-Time Package Height Profiling And Edge Detection Processing Module within a LDIP subsystem to automatically process raw data received by the LDIP subsystem and generate, as output, time-stamped data sets that are transmitted to a camera control computer which automatically processes the received time-stamped data sets and generates real-time camera control signals that drive the focus and zoom lens group translators within a high-speed auto-focus/auto-zoom digital camera subsystem so that the camera subsystem automatically captures digital images having (1) square pixels (i.e. 1:1 aspect ratio) independent of package height or velocity, and (2) constant image resolution measured in dots per inch (dpi) independent of package height or velocity.

563. The unitary PLIIM-based object identification and attribute acquisition system of claim 562, where in said Real-Time Package Height Profile And Edge Detection Processing Module within the LDIP subsystem, each sampled row of raw range data collected by the LDIP subsystem is processed to produce a data set (i.e. containing data elements representative of the current time-stamp, the package height, the position of the left and right edges of the package edges, the coordinate subrange where height values exhibit maximum range intensity variation and the current package velocity) which is then transmitted to

the camera control computer for processing and generation of real-time camera control signals that are transmitted to the auto-focus/auto-zoom digital camera subsystem.

564. A real-time object height profiling method for use in a LDIP sub employed in a PLIIM-based imaging system having a camera control computer for controlling the focusing optics of said PLIIM-based imaging system, comprising the steps of:
(a) an LDIP subsystem, detecting the range intensity (I_i) and phase angle (ϕ_i) data samples taken from a laser beam scanned off an object moving along a conveyor belt structure, said data samples being collected at various scan angles (α_I) by said LDIP Subsystem during each LDIP scan cycle;
b) at said LDIP subsystem, using the range intensity and phase angle data samples collected in step (a) in order to compute the range (R_i) and polar angle ($\O_i$) of said object at said scan angles, with respect to a polar coordinate reference system;
(c) at said LDIP subsystem, computing the height (y_i) and position (x_i) of said object at each scan angle (α_I) during each LDIP scan cycle, so as to produce a time-stamped data set at said LDIP scan cycle, for transmission to and use by said camera control computer in controlling the focusing optics in said PLIIM-based imaging system.

565. A method of automatically processing the received time-stamped data sets and generating real-time camera control signals that drive the focus and zoom lens group translators within a high-speed auto-focus/auto-zoom digital camera subsystem (i.e. the IFD module) so that the camera subsystem automatically captures digital images having constant image resolution measured in dots per inch (DPI) independent of package height or velocity.

566. A method of controlling an auto-focus/auto-zoom digital camera subsystem in a PLIIM-based imaging and profiling subsystem having a camera control computer, said method comprising the steps of: determining the positions to which focus and zoom lens groups in the PLIIM-based imaging and profiling system are moved; and generating and supplying real-time camera control signals to said camera control computer so as to operate focus and zoom lens group translators within said auto-focus/auto-zoom digital camera subsystem (i.e. the IFD module) so that said focus and zoom lens groups in said PLIIM-based imaging and profiling system are moved to said determined positions so that said camera subsystem automatically captures focused digital images having constant image resolution measured in dots per inch (DPI) independent of package height or velocity.

567. A method of controlling the operation of a PLIIM-based imaging system having (i) a planar laser illumination array (PLIA) for producing a planar laser illumination beam (PLIB) that is projected onto an object moving past said PLIIM-based imaging system, and (ii) a linear image detection array with auto zooming and focusing image forming optics for providing said linear image detection array with a field of view (FOV) that is coplanar with said PLIB illuminating said object, said method comprising the steps of:

(a) detecting the velocity of an object and its distance from said PLIIM-based imaging system;

(b) using said detected height and velocity of said object to determine the photo-integration time period for said linear image detection array which will ensure that digital images captured by said linear image detection array will have substantially square pixels (i.e. have 1:1 pixel aspect ratio);

(c) generating control signals based on said determined photo-integration time period; and

(d) using said control signals to provide said linear image detection array with said predetermined photo-integration time period so as to ensure that digital images captured by said linear image detection array will have substantially square pixels.

568. A PLIIM-based imaging system comprising:

a planar laser illumination array (PLIA) for producing a planar laser illumination beam (PLIB) that is projected onto an object moving past said PLIIM-based imaging system;

a linear image detection array with auto zooming and focusing image forming optics for providing said linear image detection array with a field of view (FOV) that is coplanar with said PLIB illuminating said object;

a laser scanning object ranging subsystem, detecting the velocity of an object and its distance from said PLIIM-based imaging and profiling system; and

a camera control computer for carrying out the following operations:

(1) using said detected height and velocity of said object to determine the photo-integration time period for said linear image detection array which will ensure that digital images captured by said linear image detection array will have substantially square pixels (i.e. have 1:1 pixel aspect ratio);

(2) generating control signals based on said determined photo-integration time period; and

(3) using said control signals to provide said linear image detection array with said predetermined photo-integration time period so as to ensure that digital images captured by said linear image detection array will have substantially square pixels.

569. A method of and apparatus for automatically compensating for viewing-angle distortion in PLIIM-based linear imaging and profiling systems which would otherwise occur when images of object surfaces are being captured as object surfaces, arranged at skewed viewing angles, move past the coplanar PLIB/FOV of such PLIIM-based linear imaging and profiling systems, configured for top and side imaging operations.

570. A method of automatically compensating for viewing-angle distortion in a linear PLIIM-based imaging system having (1) a linear camera subsystem having a linear image detection array with a variable line rate, (2) a laser based ranging subsystem, and (3) a camera control computer, said method comprising the steps of:

(a) using said laser based ranging subsystem to measure the range of points on a surface of an object moving past said PLIIM-based imaging system;

(b) in said camera control computer, using said measured range of points to compute the slope (i.e. surface gradient) of said object surface; an

(c) using said camera control computer to dynamically adjusting the line rate of said linear camera subsystem, in automatic response to said computed slope of said object surface, so as to automatically compensate for viewing-angle distortion in said linear PLIIM-based imaging system.

571. A linear PLIIM-based imaging system provided with a means for automatically compensating for viewing-angle distortion, said linear PLIIM-based imaging system comprising:

a linear camera subsystem having a linear image detection array with a variable line rate;

a laser based ranging subsystem for measuring the range of points on a surface of an object moving past said PLIIM-based imaging system; and

a camera control computer for performing the following operations: (1) using said measured range of points to compute the slope (i.e. surface gradient) of said object surface; and (2) dynamically adjusting the line rate of said linear camera subsystem, in automatic response to said computed slope of said object surface, so as to automatically compensate for viewing-angle distortion in said linear PLIIM-based imaging system.

572. A method of and apparatus for performing automatic recognition of graphical intelligence contained in 2-D images captured from arbitrary 3-D object surfaces.

573. A PLIIM-based object identification and attribute acquisition system which is capable of performing a novel method of recognizing graphical intelligence (e.g. symbol character strings and/or bar code symbols) contained in high-resolution 2-D images lifted from arbitrary moving 3-D object surfaces, by constructing high-resolution 3-D images of the object from (i) linear 3-D surface profile maps drawn by the LDIP subsystem in the PLIIM-based profiling and imaging system, and (ii) high-resolution linear images lifted by the PLIIM-based linear imaging subsystem thereof.

574. The PLIIM-based object identification and attribute acquisition system of claim 573, wherein the method of graphical intelligence recognition employed therein is carried out in an image processing computer associated with the PLIIM-based object identification and attribute acquisition system, and involves (i) producing 3-D polygon-mesh surface models of the moving target object, (ii) projecting pixel rays in 3-D space from each pixel in each captured high-resolution linear image, and (iii) computing the points of intersection between these pixel rays and the 3-D polygon-mesh model so as to produce a high-resolution 3-D image of the target object.

575. A method of recognizing graphical intelligence recorded on planar substrates that have been physically distorted as a result of either (i) application of the graphical intelligence to an arbitrary 3-D object surface, or (ii) deformation of a 3-D object on which the graphical intelligence has been rendered.

576. The method of claim 575, which is capable of "undistorting" any distortions imparted to the graphical intelligence while being carried by the arbitrary 3-D object surface due to, for example, non-planar surface characteristics.

577. A method of recognizing graphical intelligence, originally formatted for application onto planar surfaces, but applied to non-planar surfaces or otherwise to substrates having surface characteristics which differ from the surface characteristics for which the graphical intelligence was originally designed without spatial distortion.

578. A method of recognizing bar coded baggage identification tags as well as graphical character encoded labels which have been deformed, bent or otherwise physically distorted.

579. A method of automatically cropping captured linear images of an object prior to image processing in an image processing computer, said method comprising steps of:

(a) determining the pixel indices (i,j) of a selected portion of a captured image which defines the "region of interest" (ROI) on a package bearing package identifying information (e.g. bar code label, textual information, graphics, etc.);

(b) using these pixel indices (i,j) to produce image cropping control commands at an camera control computer;

(c) transmitting said image cropping control commands to an image processing computer at which said captured image has been buffered;

(d) using said image cropping commands at said image processing computer to crop pixels in said ROI of said captured image;

(e) processing said cropped pixels using image-based bar code symbol decoding and/or OCR-based image processing operations.

580. Apparatus for automatically cropping captured linear images of an object prior to image processing in an image processing computer, said apparatus comprising:

means for determining the pixel indices (i,j) of a selected portion of a captured image which defines the "region of interest" (ROI) on a package bearing package identifying information;

means for using these pixel indices (i,j) to produce image cropping control commands at an camera control computer;

means for transmitting said image cropping control commands to an image processing computer at which said captured image has been buffered; and

means for using said image cropping commands at said image processing computer to crop pixels in said ROI of said captured image;

processing said cropped pixels using image-based bar code symbol decoding and/or OCR-based image processing operations.

581. A method of and apparatus for performing automatic recognition of graphical intelligence contained in 2-D images captured from arbitrary 3-D object surfaces.

582. Apparatus in the form of a PLIIM-based object identification and attribute acquisition system which is capable of performing a novel method of recognizing graphical intelligence (e.g. symbol character strings and/or bar code symbols) contained in high-resolution 2-D images lifted from arbitrary moving 3-D object surfaces, by constructing high-resolution 3-D images of the object from (i) linear 3-D surface profile maps drawn by the LDIP subsystem in the PLIIM-based profiling and imaging system, and (ii) high-resolution linear images lifted by the PLIIM-based linear imaging subsystem thereof.

583. A PLIIM-based object identification and attribute acquisition system, wherein the method of graphical intelligence recognition employed therein is carried out in an image processing computer associated with the PLIIM-based object identification and attribute acquisition system, and involves (i) producing 3-D polygon-mesh surface models of the moving target object, (ii) projecting pixel rays in 3-D space from each pixel in each captured high-resolution linear image, and (iii) computing the points of intersection between these pixel rays and the 3-D polygon-mesh model so as to produce a high-resolution 3-D image of the target object.

584. A method of recognizing graphical intelligence recorded on planar substrates that have been physically distorted as a result of either (i) application of the graphical intelligence to an arbitrary 3-D object surface, or (ii) deformation of a 3-D object on which the graphical intelligence has been rendered.

585. A method of "undistorting" any distortions imparted to the graphical intelligence while being carried by the arbitrary 3-D object surface due to, for example, non-planar surface characteristics.

586. A method of recognizing graphical intelligence, originally formatted for application onto planar surfaces, but applied to non-planar surfaces or otherwise to substrates having surface characteristics which differ from the surface characteristics for which the graphical intelligence was originally designed without spatial distortion.

587. A method of recognizing bar coded baggage identification tags as well as graphical character encoded labels which have been deformed, bent or otherwise physically distorted.

588. Apparatus in the form of a PLIIM-based object identification and attribute acquisition system which is capable of performing a novel method of recognizing graphical intelligence (e.g. symbol character strings and/or bar code symbols) contained in high-resolution 2-D images lifted from arbitrary moving 3-D object surfaces, by constructing high-resolution 3-D images of the object from (i) linear 3-D surface profile maps drawn by the LDIP subsystem in the PLIIM-based profiling and imaging system, and (ii) high-resolution linear images lifted by the PLIIM-based linear imaging subsystem thereof.

589. A PLIIM-based object identification and attribute acquisition system, wherein the method of graphical intelligence recognition employed therein is carried out in an image processing computer associated with the PLIIM-based object identification and attribute acquisition system, and involves (i) producing 3-D polygon-mesh surface models of the moving target object, (ii) projecting pixel rays in 3-D space from each pixel in each captured high-resolution linear image, and (iii) computing the points of intersection between these pixel rays and the 3-D polygon-mesh model so as to produce a high-resolution 3-D image of the target object.

590. A method of performing automatic recognition of graphical intelligence contained in 2-D images captured from arbitrary 3-D object surfaces.

591. Apparatus for performing automatic recognition of graphical intelligence contained in 2-D images captured from arbitrary 3-D object surfaces.

592. A PLIIM-based object identification and attribute acquisition system which is capable of performing a novel method of recognizing graphical intelligence (e.g. symbol character strings and/or bar code symbols) contained in high-resolution 2-D images lifted from arbitrary moving 3-D object surfaces, by constructing high-resolution 3-D images of the object from (i) linear 3-D surface profile maps drawn by the LDIP subsystem in the PLIIM-based profiling and imaging system, and (ii) high-resolution linear images lifted by the PLIIM-based linear imaging subsystem thereof.

593. The PLIIM-based object identification and attribute acquisition system of claim 592, wherein the method of graphical intelligence recognition employed therein is carried out in an image processing computer associated with the PLIIM-based object identification and attribute acquisition system, and involves (i) producing 3-D polygon-mesh surface models of the moving target object, (ii) projecting pixel rays in 3-D space from each pixel in each captured high-resolution linear image, and (iii) computing the points of intersection between these pixel rays and the 3-D polygon-mesh model so as to produce a high-resolution 3-D image of the target object.

594. A four-sided tunnel-type object identification and attribute acquisition (PID) system constructed by arranging about a high-speed package conveyor belt subsystem, one PLIIM-based PID unit and three modified PLIIM-based PID units (without the LDIP Subsystem), wherein the LDIP subsystem in the top PID unit is configured as the master unit to detect and dimension packages transported along the belt, while the bottom PID unit is configured as a slave unit to view packages through a small gap between conveyor belt sections and the side PID units are configured as slave units to view packages from side angles slightly downstream from the master unit, and wherein all of the PID units are operably connected to an Ethernet control hub (e.g. contained within one of the slave units) of a local area network (LAN) providing high-speed data packet communication among each of the units within the tunnel system;

595. The tunnel-type system of claim 594, embedded within a first-type LAN having an Ethernet control hub (e.g. contained within one of the slave units).

596. The tunnel-type system of claim 594, embedded within a second-type LAN having an Ethernet control hub and an Ethernet data switch (e.g. contained within one of the slave units), and a fiber-optic (FO) based network, to which a keying-type computer workstation is connected at a remote distance within a package counting facility.

597. A tunnel-type object identification and attribute acquisition (PIAD) system comprising a plurality of PLIIM-based package identification (PID) units arranged about a high-speed package conveyor belt structure, wherein the PID units are integrated within a high-speed data communications network having a suitable network topology and configuration.

598. A tunnel-type PIAD system, wherein the top PID unit includes a LDIP subsystem, and functions as a master PID unit within the tunnel system, whereas the side and bottom PID units (which are not provided with a LDIP subsystem) function as slave PID units and are programmed to receive package dimension data (e.g. height, length and width coordinates) from the master PID unit, and automatically convert (i.e. transform) on a real-time basis these package dimension coordinates into their local coordinate reference frames for use in dynamically controlling the zoom and focus parameters of the camera subsystems employed in the tunnel-type system.

599. A tunnel-type system, wherein the camera field of view (FOV) of the bottom PID unit is arranged to view packages through a small gap provided between sections of the conveyor belt structure.

600. A CCD camera-based tunnel system comprising auto-zoom/auto-focus CCD camera subsystems which utilize a "package-dimension data" driven camera control computer for automatic controlling the camera zoom and focus characteristics on a real-time manner.

601. A CCD camera-based tunnel-type system, wherein the package-dimension data driven camera control computer involves (i) dimensioning packages in a global coordinate reference system, (ii) producing package coordinate data referenced to the global coordinate reference system, and (iii) distributing the package coordinate data to local coordinate references frames in the system for conversion of the package coordinate data to local coordinate reference frames, and subsequent use in automatic camera zoom and focus control operations carried out upon the dimensioned packages.

602. A CCD camera-based tunnel-type system, wherein a LDIP subsystem within a master camera unit generates (i) package height, width, and length coordinate data and (ii) velocity data, referenced with respect to the global coordinate reference system R_{global}, and these package dimension data elements are

transmitted to each slave camera unit on a data communication network, and once received, the camera control computer within the slave camera unit uses its preprogrammed homogeneous transformation to converts there values into package height, width, and length coordinates referenced to its local coordinate reference system.

603.A CCD camera-based tunnel-type system, wherein a camera control computer in each slave camera unit uses the converted package dimension coordinates to generate real-time camera control signals which intelligently drive its camera's automatic zoom and focus imaging optics to enable the intelligent capture and processing of image data containing information relating to the identify and/or destination of the transported package.

604. A camera-based object identification and attribute acquisition subsystem comprising a system architecture of a slave units in relation to a master unit, wherein (1) the package height, width, and length coordinates data and velocity data elements (computed by the LDIP subsystem within the master unit) are produced by the master unit and defined with respect to the global coordinate reference system, and (2) these package dimension data elements are transmitted to each slave unit on the data communication network, converted into the package height, width, and length coordinates, and used to generate real-time camera control signals which intelligently drive the camera subsystem within each slave unit, and (3) the package identification data elements generated by any one of the slave units are automatically transmitted to the master slave unit for time-stamping, queuing, and processing to ensure accurate package dimension and identification data element linking operations.

605. A tunnel-type system wherein package dimension data (i.e. height, width, and length coordinates) is (i) centrally computed by a master unit and referenced to a global coordinate reference frame, (ii) transmitted over the data network to each slave unit within the system, and (iii) converted to the local coordinate reference frame of each slave unit for use by its camera control computer to drive its automatic zoom and focus imaging optics in real-time manner.

606. An angle measurement device integrated into the housing and support structure of a slave unit in a tunnel-type system, thereby enabling technicians to measure the pitch and yaw angle of the local coordinate system symbolically embedded within each slave unit.

607. A Data Element Queuing, Handling, Processing And Linking Mechanism for integration in an Object Identification and Attribute Acquisition System, wherein a programmable data element tracking and linking (i.e. indexing) module is provided for linking (1) object identity data to (2) corresponding object attribute data (e.g. object dimension-related data, object-weight data, object-content data, object-interior data, etc.) in both singulated and non-singulated object transport environments.

608. Data Element Queuing, Handling, Processing And Linking Mechanism for integration in an Object Identification and Attribute Acquisition System, wherein the Data Element Queuing, Handling, Processing And Linking Mechanism can be easily programmed to enable underlying functions required by the object detection, tracking, identification and attribute acquisition capabilities specified for the Object Identification and Attribute Acquisition System.

609. A Data-Element Queuing, Handling And Processing Subsystem for use in the PLIIM-based system, wherein object identity data element inputs (e.g. from a bar code symbol reader, RFID reader, or the like) and object attribute data element inputs (e.g. object dimensions, weight, x-ray analysis, neutron beam analysis, and the like) are supplied to a Data Element Queuing, Handling, Processing And Linking Mechanism contained therein via an I/O unit so as to generate as output, for each object identity data element supplied as input, a combined data element comprising an object identity data element, and one or more object attribute data elements (e.g. object dimensions, object weight, x-ray analysis, neutron beam analysis, etc.) collected by the I/O unit of the system.

610. A Data Element Queuing, Handling, Processing And Linking Mechanism which automatically receives object identity data element inputs (e.g. from a bar code symbol reader, RFID-tag reader, or the like) and object attribute data element inputs (e.g. object dimensions, object weight, x-ray images, Pulsed Fast Neutron Analysis (PFNA) image data captured by a PFNA scanner by Ancore, and QRA image data captured by a QRA scanner by Quantum Magnetics, Inc.), and automatically generates as output, for each object identity data element supplied as input, a combined data element comprising (i) an object identity data element, and (ii) one or more object attribute data elements (e.g. object dimensions, object weight, x-ray analysis, neutron beam analysis, etc.) collected and supplied to the data element queuing, handling and processing subsystem.

611. A Data-Element Queuing, Handling And Processing Subsystem employed in a PLIIM-based system comprising:

Data Element Queuing, Handling, Processing And Linking Mechanism;

object identity data element inputs (e.g. from a bar code symbol reader, RFID reader, or the like); and object attribute data element inputs (e.g. object dimensions, weight, x-ray analysis, neutron beam analysis, and the like) are supplied to said Data Element Queuing, Handling, Processing And Linking Mechanism via an I/O unit so as to generate as output, for each object identity data element supplied as input, a combined data element comprising an object identity data element, and one or more object attribute data elements (e.g. object dimensions, object weight, x-ray analysis, neutron beam analysis, etc.) collected by the I/O unit of the system.

612. A stand-alone Object Identification And Attribute Information Tracking And Linking Computer System for use in diverse systems generating and collecting streams of object identification information and object attribute information.

613. A stand-alone Object Identification And Attribute Information Tracking And Linking Computer for use at passenger and baggage screening stations alike.

614. An Object Identification And Attribute Information Tracking And Linking Computer having a programmable data element queuing, handling and processing and linking subsystem, wherein each object identification data input (e.g. from a bar code reader or RFID reader) is automatically attached to each corresponding object attribute data input (e.g. object profile characteristics and dimensions, weight, X-ray images, etc.) generated in the system in which the computer is installed.

615. An Object Identification And Attribute Information Tracking And Linking Computer System, realized as a compact computing/network communications device having a set of comprises: a housing of compact construction; a computing platform including a microprocessor, system bus, an associated memory architecture (e.g. hard-drive, RAM, ROM ~~and cache~~ memory), and operating system software, networking software, etc.; a LCD display panel mounted within the wall of the housing, and interfaced with the system bus by interface drivers; a membrane-type keypad also mounted within the wall of the housing below the LCD panel, and interfaced with the system bus by interface drivers; a network controller card operably connected to the microprocessor by way of interface drivers, for supporting high-speed data communications using any one or more networking protocols (e.g. Ethernet, Firewire, USB, etc.); a first set of data input port connectors mounted on the exterior of the housing, and configurable to receive "object identity" data from an object identification device (e.g. a bar code reader and/or an RFID reader) using a networking protocol such as Ethernet; a second set of the data input port connectors mounted on the exterior of the housing, and configurable to receive "object attribute" data from external data generating sources (e.g. an LDIP Subsystem, a PLIIM-based imager, an x-ray scanner, a neutron beam scanner, MRI scanner and/or a QRA scanner) using a networking protocol such as Ethernet; a network connection port for establishing a network connection between the network controller and the communication medium to which the Object Identification And Attribute Information Tracking And Linking Computer System is connected; data element queuing, handling, processing and linking software stored on the hard-drive, for enabling the automatic queuing, handling, processing, linking and transporting of object identification (ID) and object attribute data elements generated within the network and/or system, to a designated database for storage and subsequent analysis; and a networking hub (e.g. Ethernet hub) operably connected to the first and second sets of data input port connectors, the network connection port, and also the network controller card, so that all networking devices connected through the networking hub can send and receive data packets and support high-speed digital data communications.

616. An Object Identification And Attribute Information Tracking And Linking Computer which can be programmed to receive two different streams of data input, namely: (i) passenger identification data input (e.g. from a bar code reader or RFID reader) used at the passenger check-in and screening station; and (ii)

corresponding passenger attribute data input (e.g. passenger profile characteristics and dimensions, weight, X-ray images, etc.) generated at the passenger check-in and screening station, and wherein each passenger attribute data input is automatically attached to each corresponding passenger identification data element input, so as to produce a composite linked output data element comprising the passenger identification data element symbolically linked to corresponding passenger attribute data elements received at the system.

617. A software-based system configuration manager (i.e. system configuration "wizard" program) which can be integrated (i) within the Object Identification And Attribute Acquisition Subsystem of the present invention, as well as (ii) within the Stand-Alone Object Identification And Attribute Information Tracking And Linking Computer System of the present invention.

618. A system configuration manager, which assists the system engineer or technician in simply and quickly configuring and setting-up an Object Identity And Attribute Information Acquisition System, as well as a Stand-Alone Object Identification And Attribute Information Tracking And Linking Computer System, using a novel graphical-based application programming interface (API).

619. A system configuration manager, wherein its API enables a systems configuration engineer or technician having minimal programming skill to simply and quickly perform the following tasks: (1) specify the object detection, tracking, identification and attribute acquisition capabilities (i.e. functionalities) which the system or network being designed and configured should possess; (2) determine the configuration of hardware components required to build the configured system or network; and (3) determine the configuration of software components required to build the configured system or network, so that it will possess the object detection, tracking, identification, and attribute-acquisition capabilities.

620. A system and method for configuring an object identification and attribute acquisition system of the present invention for use in a PLIIM-based system or network, wherein the method employs a graphical user interface (GUI) which presents queries about the various object detection, tracking, identification and attribute-acquisition capabilities to be imparted to the PLIIM-based system during system configuration, and wherein the answers to the queries are used to assist in the specification of particular capabilities of the Data Element Queuing, Handling and Processing Subsystem during system configuration process.

621. A method of and apparatus for measuring, in the field, the pitch and yaw angles of each slave Package Identification (PID) unit in the tunnel system, as well as the elevation (i.e. height) of each such PID unit, relative to the local coordinate reference frame symbolically embedded within the local PID unit.

622. Apparatus realized as angle-measurement (e.g. protractor) devices integrated within the structure of each slave and master PID housing and the support structure provided to support the same within the tunnel system, enabling the taking of such field measurements (i.e. angle and height readings) so that the precise coordinate location of each local coordinate reference frame (symbolically embedded within each PID unit) can be precisely determined, relative to the master PID unit.

623. An angle measurement device integrated into the structure of a PID unit by providing a pointer or indicating structure (e.g. arrow) on the surface of the housing of the PID unit, while mounting angle-measurement indicator on the corresponding support structure used to support the housing above the conveyor belt of the tunnel system.

624. . A hand-supportable mobile-type PLIIM-based 3-D digitization device capable of producing 3-D digital data models and 3-D geometrical models of laser scanned objects, for display and viewing on a LCD view finder integrated with the housing (~~or on~~ the display panel of a computer graphics workstation), wherein a single planar laser illumination beam (PLIB) and a single amplitude modulated (AM) laser scanning beam are transported through the 3-D scanning volume of the scanning device so as to optically scan the object under analysis and capture linear images and range-profile maps thereof relative to a coordinate reference system symbolically embodied within the scanning device, for subsequent reconstruction therein using computer-assisted tomographic (CAT) techniques to generate a 3-D geometrical model of the object for display, viewing and use in diverse applications.

625. A transportable PLIIM-based 3-D digitization device ("3-D digitizer") capable of producing 3-D digitized data models of scanned objects, for viewing on a LCD view finder integrated with the device housing (or on the display panel of an external computer graphics workstation), wherein the object under analysis is controllably rotated through a single planar laser illumination beam (PLIB) and a single amplitude modulated (AM) laser scanning beam generated by the 3-D digitization device so as to optically scan the object and automatically capture linear images and range-profile maps thereof relative to a coordinate reference system symbolically embodied within the 3-D digitization device, for subsequent reconstruction therein using computer-assisted tomographic (CAT) techniques to generate a 3-D digitized data model of the object for display, viewing and use in diverse applications.

626. A transportable PLIIM-based 3-D digitizer having optically-isolated light transmission windows for transmitting laser beams from a PLIIM-based object identification subsystem and an LDIP-based object detection and profiling/dimensioning subsystem embodied within the transportable housing of the 3-D digitizer.

627. A transportable PLIIM-based 3-D digitization device ("3-D digitizer") capable of producing 3-D digitized data models of scanned objects, for viewing on a LCD view finder integrated with the device housing (or on the display panel of an external computer graphics workstation), wherein a single planar

laser illumination beam (PLIB) and a single amplitude modulated (AM) laser scanning beam are generated by the 3-D digitization device and automatically swept through the 3-D scanning volume in which the object under analysis resides so as to optically scan the object and automatically capture linear images and range-profile maps thereof relative to a coordinate reference system symbolically embodied within the 3-D digitization device, for subsequent reconstruction therein using computer-assisted tomographic (CAT) techniques to generate a 3-D digitized data model of the object for display, viewing and use in diverse applications.

628. An Internet-based remote monitoring, configuration and service (RMCS) system and method which is capable of monitoring, configuring and servicing PLIIM-based networks, systems and subsystems of the present invention using any Internet-based client computing subsystem.

629. An Internet-based remote monitoring, configuration and service (RMCS) system and associated method which enables a systems or network engineer or service technician to use any Internet-enabled client computing machine to remotely monitor, configure and/or service any PLIIM-based network, system or subsystem of the present invention in a time-efficient and cost-effective manner.

630. A RMCS system and method, which enables an engineer, service technician or network manager, while remotely situated from the system or network installation requiring service, to use any Internet-enabled client machine to: (1) monitor a robust set of network, system and subsystem parameters associated with any tunnel-based network installation (i.e. linked to the Internet through an ISP or NSP); (2) analyze these parameters to trouble-shoot and diagnose performance failures of networks, systems and/or subsystems performing object identification and attribute acquisition functions; (3) reconfigure and/or tune some of these parameters to improve network, system and/or subsystem performance; (4) make remote service calls and repairs where possible over the Internet; and (5) instruct local service technicians on how to repair and service networks, systems and/or subsystems performing object identification and attribute acquisition functions.

631. An Internet-based RMCS system and method, wherein the simple network management protocol (SNMP) is used to enable network management and communication between (i) SNMP agents, which are built into each node (i.e. object identification and attribute acquisition system) in the PLIIM-based network, and (ii) SNMP managers, which can be built into a LAN http/Servlet Server as well as any Internet-enabled client computing machine functioning as the network management station (NMS) or management console.

632. An Internet-based remote monitoring, configuration and service (RMCS) system and associated method, wherein servlets in an HTML-encoded RMCS management console are used to trigger SNMP agent operations within devices managed within a tunnel-based LAN.

633. An Internet-based remote monitoring, configuration and service (RMCS) system and associated method, wherein a servlet embedded in the RMCS management console can simultaneously invoke multiple methods on the server side of the network, to monitor (i.e. read) particular variables (e.g. parameters) in each object identification and attribute acquisition subsystem, and then process these monitored parameters for subsequent storage in a central MIB in the and/or display.

634. An Internet-based remote monitoring, configuration and service (RMCS) system and associated method, wherein a servlet embedded in the RMCS management console can invoke a method on the server side of the network, to control (i.e. write) particular variables (e.g. parameters) in a particular device being managed within the tunnel-based LAN.

635. An Internet-based remote monitoring, configuration and service (RMCS) system and associated method, wherein a servlet embedded in the RMCS management console can invoke a method on the server side of the network, to control (i.e. write) particular variables (e.g. parameters) in a particular device being managed within the tunnel-based LAN.

636. An Internet-based remote monitoring, configuration and service (RMCS) system and associated method, wherein a servlet embedded in the RMCS management console can invoke a method on the server side of the network, to determine which variables a managed device supports and to sequentially gather information from variable tables for processing and storage in a central MIB in database.

637. An Internet-based remote monitoring, configuration and service (RMCS) system and associated method, wherein a servlet embedded in the RMCS management console can invoke a method on the server side of the network, to detect and asynchronously report certain events to the RCMS management console.

638. A automatic vehicle identification (AVI) system constructed using a pair of PLIIM-based imaging and profiling subsystems taught herein.

639. A automatic vehicle identification (AVI) system constructed using only a single PLIIM-based imaging and profiling subsystem taught herein, and an electronically-switchable PLIB/FOV direction module attached to the PLIIM-based imaging and profiling subsystem.

640. An automatic vehicle classification (AVC) system constructed using a several PLIIM-based imaging and profiling subsystems taught herein, mounted overhead and laterally along the roadway passing through the AVC system.

641. An automatic vehicle identification and classification (AVIC) system constructed using PLIIM-based imaging and profiling subsystems taught herein.

642. An x-ray parcel scanning-tunnel system, wherein the interior space of packages, parcels, baggage or the like, are automatically inspected by x-radiation beams to produce x-ray images which are automatically linked to object identity information by the object identity and attribute acquisition subsystem embodied within the x-ray parcel scanning-tunnel system.

643. A x-ray cargo scanning-tunnel system, wherein the interior space of cargo containers, transported by tractor trailer, rail, or other by other means, are automatically inspected by x-radiation energy beams to produce x-ray images which are automatically linked to cargo container identity information by the object identity and attribute acquisition subsystem embodied within the system.

644. A PLIIM-equipped x-ray parcel scanning-tunnel system of the present invention operably connected to a RDBMS which is in data communication with one or more remote intelligence RDBMSs connected to the infrastructure of the Internet, wherein the interior space of packages, parcels, baggage or the like, are automatically inspected by x-radiation beams to produce x-ray images which are automatically linked to object identity information by the PLIIM-based object identity and attribute acquisition subsystem embodied within the PLIIM-equipped x-ray parcel scanning-tunnel system;

645. A PLIIM-equipped x-ray parcel scanning-tunnel system of a Pulsed Fast Neutron Analysis (PFNA) parcel scanning-tunnel system, wherein the interior space of packages, parcels, baggage or the like, are automatically inspected by neutron-beams to produce neutron-beam images which are automatically linked to object identity information by the object identity and attribute acquisition subsystem embodied within the PFNA parcel scanning-tunnel system.

646. A PLIIM-equipped Pulsed Fast Neutron Analysis (PFNA) parcel scanning-tunnel system of the present invention operably connected to a RDBMS which is in data communication with one or more remote intelligence RDBMSs operably connected to the infrastructure of the Internet, wherein the interior space of packages, parcels, baggage or the like, are automatically inspected by neutron-beams to produce neutron-beam images which are automatically linked to object identity information by the PLIIM-based object identity and attribute acquisition subsystem embodied within the PLIIM-equipped PFNA parcel scanning-tunnel system;.

647. A Quadrupole Resonance (QR) parcel scanning-tunnel system, wherein the interior space of packages, parcels, baggage or the like, are automatically inspected by low-intensity electromagnetic radio waves to produce digital images which are automatically linked to object identity information by the object identity and attribute acquisition subsystem embodied within the PLIIM-equipped QR parcel scanning-tunnel system.

648. A PLIIM-equipped Quadrupole Resonance (QR) parcel scanning-tunnel system operably connected to a RDBMS which is in data communication with one or more remote intelligence RDBMSs connected to the infrastructure of the Internet, wherein the interior space of packages, parcels, baggage or the like, are automatically inspected by low-intensity electromagnetic radio waves to produce digital images which are automatically linked to object identity information by the PLIIM-based object identity and attribute acquisition subsystem embodied within the PLIIM-equipped QR parcel scanning-tunnel system.

649. An airport security system comprising:

at least one PLIIM-based passenger identification and profiling camera subsystem, for capturing a digital image of the face of each passenger to board an aircraft at the airport, (ii) capturing a digital profile of his or her face and head (and possibly body) using the LDIP subsystem employed therein, (iii) capturing a digital image of the passenger's identification card(s), (iii) indexing such passenger attribute information with the corresponding passenger identification (PID) number encoded within the PID bar code symbol that is printed on a passenger identification (PID) bracelet affixed to the passenger's hand at the passenger check-in station, and to be worn thereby during the entire duration of the passenger's scheduled flight;

a passenger identification (PID) bar code symbol and baggage identification (BID) bar code symbol dispensing subsystem, installed at the passenger check-in station, for dispensing (i) the PID bar code symbol and bracket to be worn by the passenger, and (ii) a unique BID bar code label for attachment to each baggage article to be carried aboard the aircraft on which the checked-in passenger will fly (or on another aircraft), wherein each BID bar code symbol assigned to baggage article is co-indexed with the PID bar code symbol assigned to the passenger checking in his or her baggage;

a tunnel-type package identification, dimensioning and tracking subsystem, including at least one PLIIM-based PID unit installed before the entry port of the X-radiation baggage scanning subsystem (or integrated therein), and also passenger and baggage data element tracking computer, for automatically (i) identifying each article of baggage by reading the baggage identification (BID) bar code symbol applied thereto at a baggage check-in station of the airport security system, (ii) dimensioning (i.e. profiling) the article of baggage, (iii) capturing a digital image 2614 of the article of baggage, (iv) indexing such baggage attribute information with the corresponding BID number encoded into the scanned BID bar code symbol, and (v) sending such BID-indexed baggage attribute information to a passenger and baggage attribute RDBMS for storage as a baggage attribute record;

an x-ray (or CT) baggage scanning subsystem installed slightly downstream from the tunnel-based system, for automatically scanning each BID bar coded article of baggage to be loaded onto an aircraft using, for example, x-radiation, gamma-radiation and/or other radiation beams, and producing visible digital images of the interior and contents of each baggage article;

said passenger and baggage attribute RDBMS, being operably connected to said PLIIM-based passenger identification and profiling camera subsystem, said baggage identification (BID) bar code symbol dispensing subsystem, the tunnel-type object identification and attribute acquisition subsystem, and said

baggage scanning subsystem, for maintaining coindexed records on passenger attribute information and baggage attribute information;
a computer-based information processing subsystem for processing passenger and baggage attribute records (e.g. text files, image files, voice files, etc.) and maintained in the RDBMS, to automatically mine and detect suspect conditions in such information records, as well as in records maintained in a remote RDBMS in communication with said processor via the Internet, which might detect a condition for alarm or security breach (e.g. explosive devices, identify suspect passengers linked to criminal activity, etc.); and
one or more security breach alarm subsystems, for detecting and issuing alarms to security personnel and/or other subsystems concerning possible security breach conditions during and after passengers and baggage are checked into an airport.

650. The airport security system of claim 649, wherein said passenger identification number is encoded within each BID bar code symbol affixed to the baggage articles carried by the passenger.

651. The airport security system of claim 649, wherein said PID and BID bar code symbols are constructed from 1-D or 2-D bar code symbologies.

652. A method of and apparatus for securing an airport system comprising the steps of:
each passenger who is about to board an aircraft at an airport, going to a check-in station with personal identification (e.g. passport, driver's license, etc.) in hand as well as articles of baggage to be carried on the aircraft by the passenger;
upon checking in with this station, issuing (1) a passenger identification bracelet bearing a PID bar code symbol, and (2) a corresponding PID bar code symbol for attachment to each package carried on the aircraft by the passenger;
creating a passenger/baggage information record in the RDBMS for each passenger and set of baggage checked into the system at the check-in station;
affixing a passenger identification (PID) bracelet to the passenger's hand at the passenger check-in station which is to be worn during the entire duration of the passenger's scheduled flight;
automatically capturing (i) a digital image of the passenger's face, head and upper body, (ii) a digital profile of his or her face and head using the LDIP subsystem employed therein, and (iii) a digital image of the passenger's identification card(s);
indexing each item of passenger attribute information with the corresponding passenger identification (PID) number encoded within the PID bar code symbol printed on the passenger identification (PID) bracelet affixed to the passenger's hand at the passenger check-in station;
conveying each BID bar coded article of baggage through the tunnel-type package identification, dimensioning and tracking subsystem installed before the entry port of the X-radiation baggage scanning subsystem (or integrated therewith), and then through the X-radiation baggage scanning subsystem;

automatically identifying, imaging, and dimensioning each bar coded article of baggage using optical radiation;
automatically imaging dimensioning each bar coded article of baggage with x-radiation;
automatically indexing each item of passenger and baggage attribute information with PID numbers and BID numbers, respectively, and storing said indexed item of passenger and baggage attribute information in the RDBMS for subsequent information processing;
detecting suspicious conditions revealed by x-ray images of baggage using an x-ray monitor adjacent the x-ray scanning subsystem;
running intelligent information processing algorithms each passenger and baggage attribute record stored in RDBMS as well as in remote RDBMSs containing passenger intelligence, in order to detect any suspicious conditions which may given concern or alarm about either a particular passenger or article of baggage presenting concern or a breach of security;
determining if a breach of security appears to have occurred based on the results of step (l);
if a breach is determined prior to flight-time, then aborting the flight related to the suspect passenger and/or baggage, using security personnel; and
if a breach is detected after an aircraft has lifted off, then informing the flight crew and pilot by radio communication of the detected security concern.

653. A method of and system for securing airports, bus terminals, ocean piers, and like passenger transportation terminals employing co-indexed passenger and baggage attribute information and post-collection information processing techniques.

654. An improved airport security screening method, wherein streams of baggage identification information and baggage attribute information are automatically generated at the baggage screening subsystem thereof, and each baggage attribute data is automatically attached to each corresponding baggage identification data element, so as to produce a composite linked data element comprising the baggage identification data element symbolically linked to corresponding baggage attribute data element(s) received at the system, and wherein the composite linked data element is transported to a database for storage and subsequent processing, or directly to a data processor for immediate processing.

655. An improved airport security system comprising (i) a passenger screening station or subsystem including a PLIIM-based passenger facial and body profiling identification subsystem, a hand-held PLIIM-based imager, and a data element queuing, handling and processing (i.e. linking) computer, (ii) a baggage screening subsystem including a PLIIM-based object identification and attribute acquisition subsystem, a x-ray scanning subsystem, and a neutron-beam explosive detection subsystems (EDS), (iii) a Passenger and Baggage Attribute Relational Database Management Subsystems (RDBMS) for storing co-indexed passenger identity and baggage attribute data elements (i.e. information files), and (iv) automated data processing subsystems for operating on co-indexed passenger and baggage data elements (i.e.

information files) stored therein, for the purpose of detecting breaches of security during and after passengers and baggage are checked into an airport terminal system.

656. A PLIIM-based (and/or LDIP-based) passenger biometric identification subsystem employing facial and 3-D body profiling/recognition techniques.

657. An airport security system comprising:
(i) a passenger screening station or subsystem including PLIIM-based passenger facial and body profiling identification subsystem, hand-held PLIIM-based imagers, and a data element linking and tracking computer,
(ii) a baggage screening subsystem including PLIIM-based object identification and attribute acquisition subsystem, a x-ray scanning subsystem, and a neutron-beam explosive detection subsystems (EDS),
(iii) a Passenger and Baggage Attribute Relational Database Management Subsystems (RDBMS) for storing co-indexed passenger identity and baggage attribute data elements (i.e. information files), and
(iv) automated data processing subsystems for operating on co-indexed passenger and baggage data elements (i.e. information files) stored therein, for the purpose of detecting breaches of security during and after passengers and baggage are checked into an airport terminal system;

658. A PLIIM-based (and/or LDIP-based) passenger biometric identification subsystem employing facial and 3-D body profiling/recognition techniques, and a metal-detection subsystem, employed at a passenger screening station in the airport security system.

659. A passenger and baggage database record created and maintained within the Passenger and Baggage RDBMS employed in the airport security system of claim 655.

660. An Object Identification And Attribute Information Tracking And Linking Computer employed at the passenger check-in and screening station in the airport security system.

661. A hardware computing and network communications platform employed in the realization of the Object Identification And Attribute Information Tracking And Linking Computer of claim 660.

662. An Object Identification And Attribute Information Tracking And Linking Computer comprising:
an input and output unit and a programmable data element queuing, handling and processing and linking subsystem, wherein each passenger identification data input (e.g. from a bar code reader or RFID reader) is automatically attached to each corresponding passenger attribute data input (e.g. passenger profile characteristics and dimensions, weight, X-ray images, etc.) generated at a passenger check-in and screening station;

663. A Data Element Queuing, Handling, and Processing Subsystem employed in an Object Identification and Attribute Acquisition System installed at the baggage screening station comprising:
an input and an output unit and a programmable data element queuing, handling and processing and linking subsystem, wherein each baggage identification data input (e.g. from a bar code reader or RFID reader) is automatically attached to each corresponding baggage attribute data input (e.g. baggage profile characteristics and dimensions, weight, X-ray images, PFNA images, QRA images, etc.) generated at said baggage screening station.

664. An airport security system of the present invention shown comprising:
(i) a passenger screening station or subsystem including PLIIM-based object identification and attribute acquisition subsystem,
(ii) a baggage screening subsystem including PLIIM-based object identification and attribute acquisition subsystem, an RDID object identification subsystem, a x-ray scanning subsystem, and pulsed fast neutron analysis (PFNA) explosive detection subsystems (EDS),
(iii) a internetworked passenger and baggage attribute relational database management subsystems (RDBMS), and
(iv) automated data processing subsystems for operating on co-indexed passenger and baggage data elements stored therein, for the purpose of detecting breaches of security during and after passengers and baggage are checked into an airport terminal system.

665. A "horizontal-type" 3-D PLIIM-based CAT scanning system capable of producing 3-D geometrical models of human beings, animals, and other objects, for viewing on a computer graphics workstation, wherein a single planar laser illumination beam (PLIB) and a single amplitude modulated (AM) laser scanning beam are controllably transported horizontally through the 3-D scanning volume disposed above the support platform of the system so as to optically scan the object under analysis and capture linear images and range-profile maps thereof relative to a global coordinate reference system, for subsequent reconstruction in the computer workstation using computer-assisted tomographic (CAT) techniques to generate a 3-D geometrical model of the object.

666. A "horizontal-type" 3-D PLIIM-based CAT scanning system capable of producing 3-D geometrical models of human beings, animals, and other objects, for viewing on a computer graphics workstation, wherein a three orthogonal planar laser illumination beams (PLIBs) and three orthogonal amplitude modulated (AM) laser scanning beams are controllably transported horizontally through the 3-D scanning volume disposed above the support platform of the system so as to optically scan the object under analysis and capture linear images and range-profile maps thereof relative to a global coordinate reference system, for subsequent reconstruction in the computer workstation using computer-assisted tomographic (CAT) techniques to generate a 3-D geometrical model of the object.

667. A "vertical-type" 3-D PLIIM-based CAT scanning system capable of producing 3-D geometrical models of human beings, animals, and other objects, for viewing on a computer graphics workstation, wherein a three orthogonal planar laser illumination beams (PLIBs) and three orthogonal amplitude modulated (AM) laser scanning beams are controllably transported vertically through the 3-D scanning volume disposed above the support platform of the system so as to optically scan the object under analysis and capture linear images and range-profile maps thereof relative to a global coordinate reference system, for subsequent reconstruction in the computer workstation using computer-assisted tomographic (CAT) techniques to generate a 3-D geometrical model of the object.

668. A PLIIM-based object identification and attribute acquisition system wherein a high-intensity ultra-violet germicide irradiator (UVGI) unit is mounted for irradiating germs and other microbial agents, including viruses, bacterial spores and the like, while parcels, mail and other objects are being automatically identified by bar code reading and/or image lift and OCR processing by said system.

669. A method and apparatus, wherein a planar laser illumination beam (PLIB) is temporal intensity modulated prior to target object illumination employing visible mode-locked laser diodes (MLLDs).

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